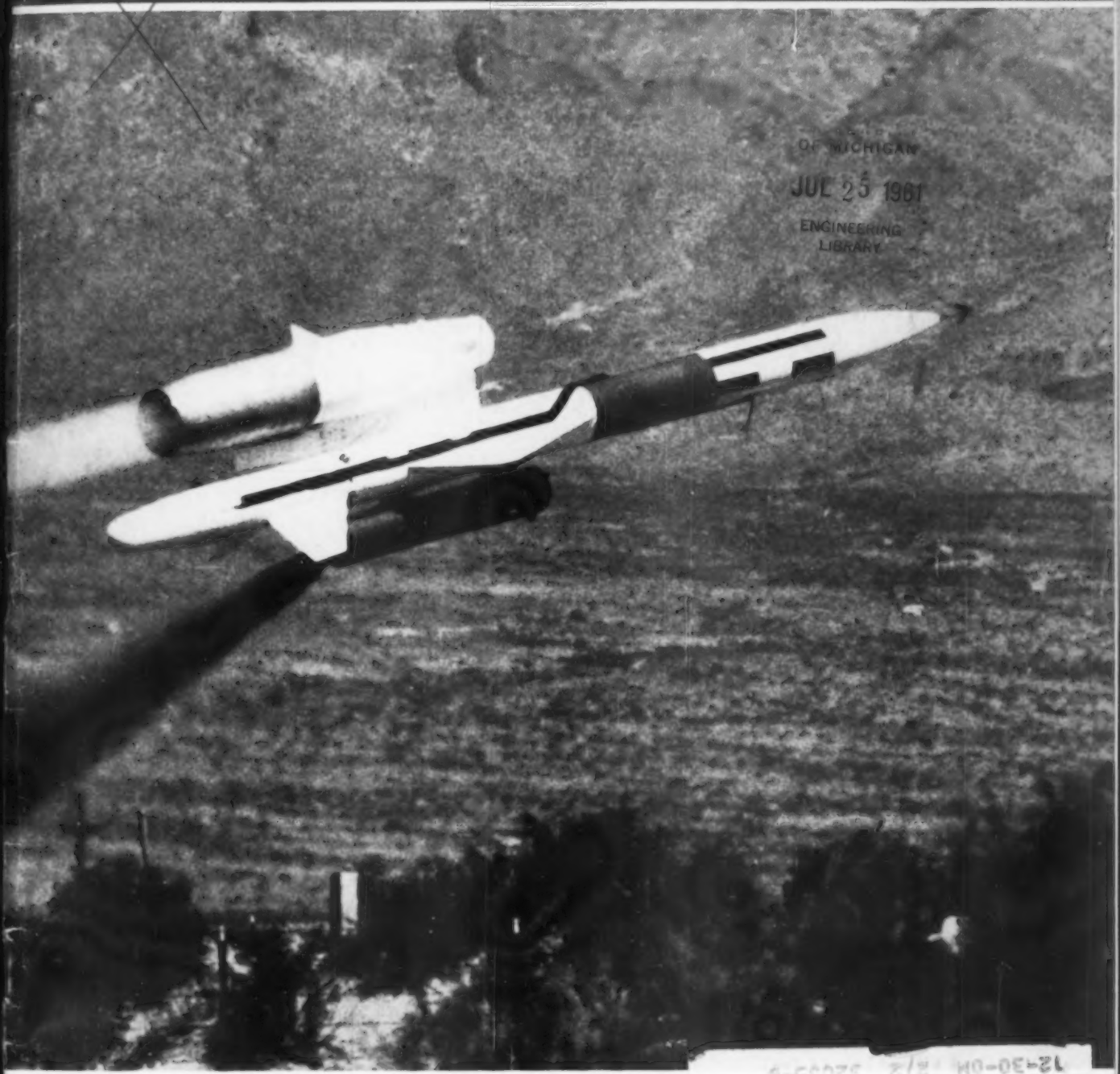
JULY 24, 1961

missiles and rockets

THE MISSILE/SPACE WEEKLY



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Testing the Army's Redhead/Roadrunner Target

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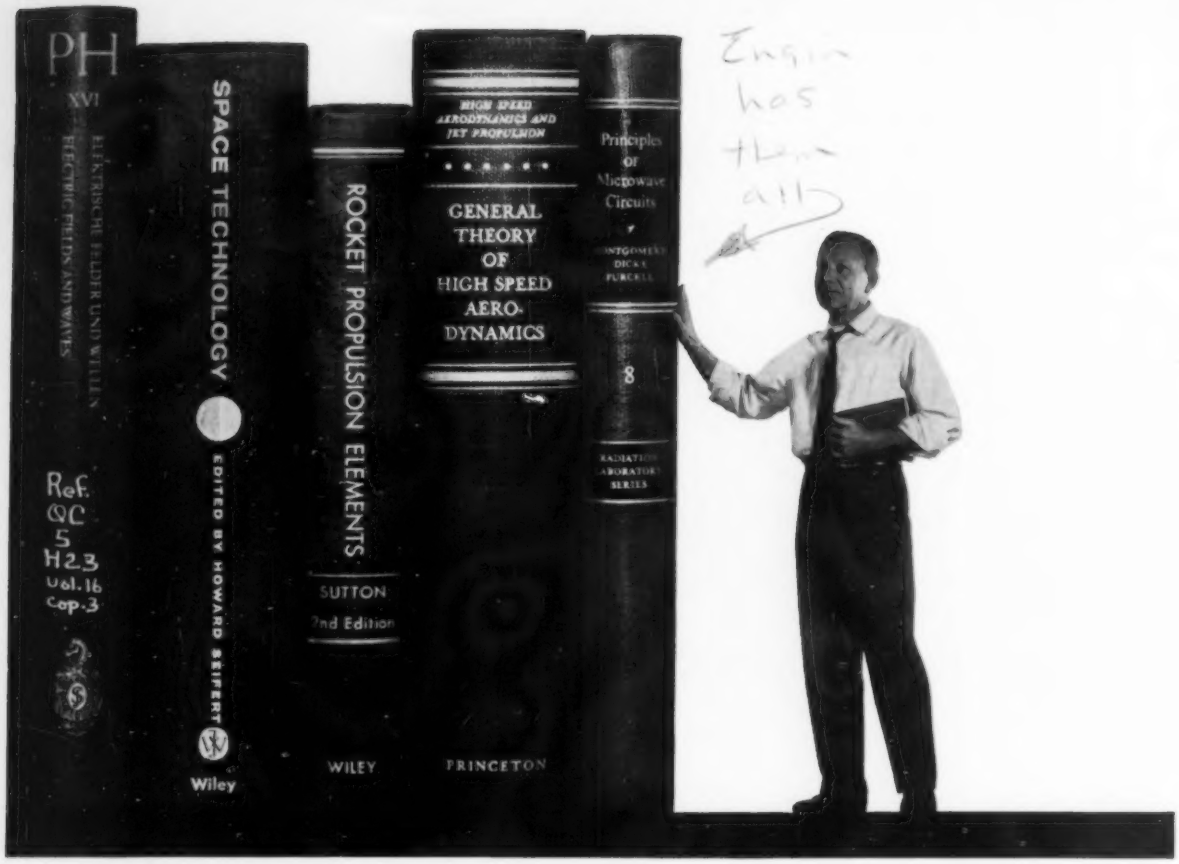

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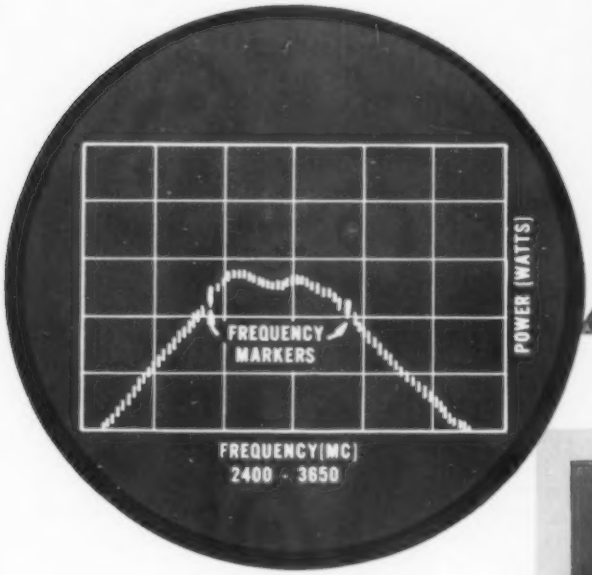

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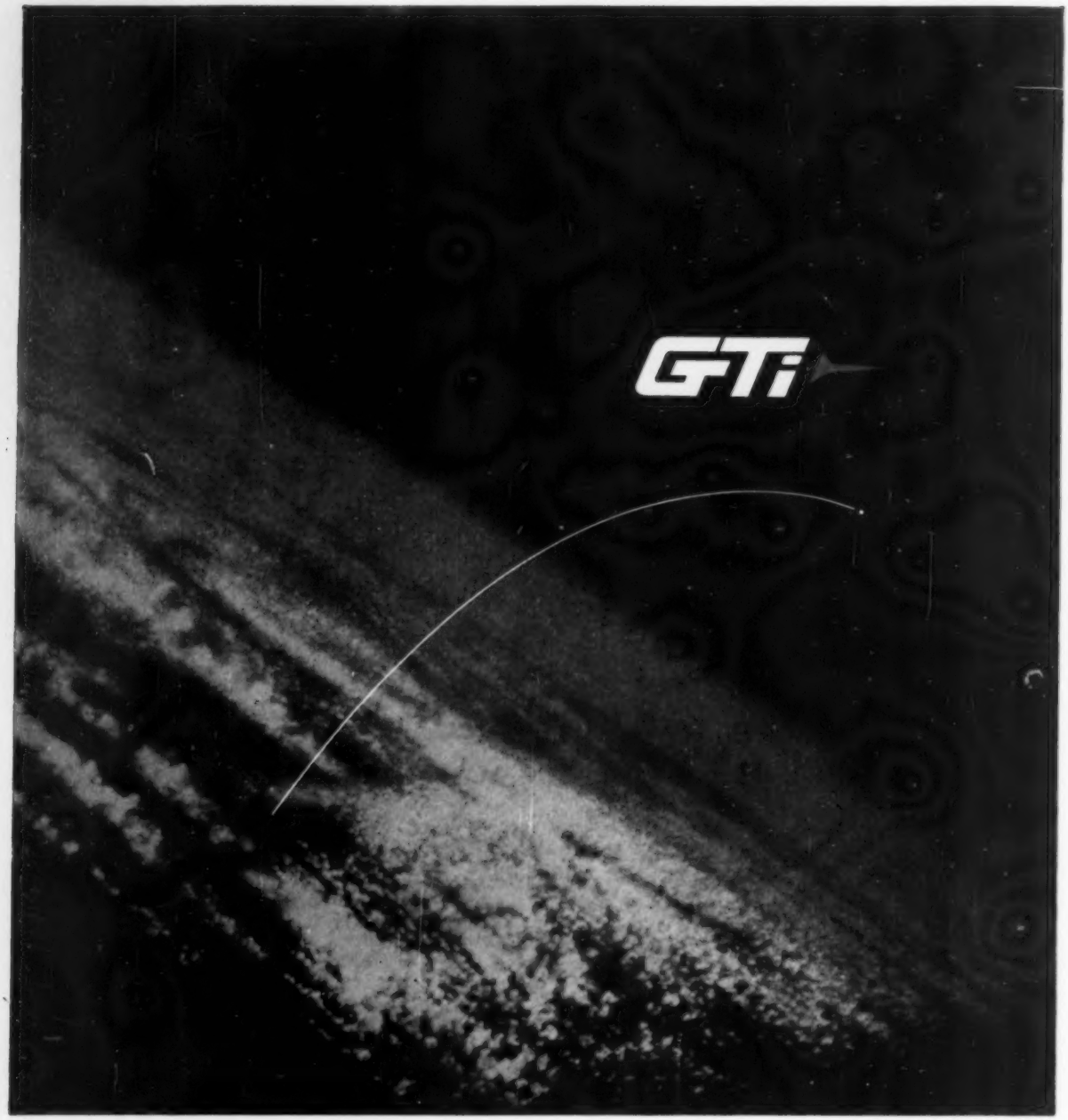

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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 9, Number 4 July 24, 1961

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THE COVER

Army's newest supersonic target missile, the North American Redhead/Roadrunner, shown in recent successful firing at White Sands Missile Range, N.M. *See p. 32.*

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† U.S. Reg. Pdg.

35,193 copies this issue

Is Defense Advertising Necessary?

There has been a lot of talk lately about the cost of the advertising done by defense contractors. One prominent Senator recently said he was greatly disturbed over heavy defense advertising expenditures. He pegged the cost "to the taxpayer" at $500 million.

This figure is many, many times the actual total of defense advertising expenditures and only a fraction of that total is recoverable. The Senator's facts are wrong; but, even more disturbing, it appears that he doesn't understand the purpose and function of sound advertising. He considers this money down the drain and thinks it should not have been spent.

There are other instances demonstrating a growing wave of anti-advertising sentiment in high government places. They indicate a lack of understanding and represent a threat both to freedom of the press and success of the Nation's defense goals.

We publish specialized business magazines and reference books. Several of these are defense oriented. They perform communications functions essential to our national goals . . . more essential now than ever before because of the complexity of today's technological and political challenges. There are other excellent magazines having the same or similar purposes. We're delighted—because competition is healthy and because there is more to be done than can be handled by any one of us.

Virtually all publications are financed, by and large, by advertising. This is healthy, too; but it is not the primary reason for defense advertising.

We believe that advertising is an effective and necessary tool for the defense contractor. The objectives of defense advertising are many: some of them obvious, others more subtle.

Sales is one obvious objective. It can be demonstrated that advertising, for some defense products, has led directly to sales. In other instances, selling is a long, complex process, where features of current products may not be as important as company reputation. In both cases, the government wants competition for defense contracts—by use of a competitive bidding system, it gets better products for less money. How is a company to compete if it is not allowed the use of sales tools—one of which is advertising?

Recruiting is another obvious objective. Will that engineer who is inspired to contribute to technological advancement in the missile/space age, for example, be interested in learning more about the kind of company he goes to work for? You bet he will, and more power to him.

The dissemination of technical information is a third, and perhaps the most important, objective. The exchange of such information is one of the biggest problems facing both government and industry. And what more effective, more economical means of disseminating necessary technical information exists than the business press? Mills Shepard, who performs readership studies on one of our publications, reports that advertisements are often read as avidly as the editorial pages. And Eastman Research, in a study released May 29, based on more than 100 surveys for 32 businesspaper clients over a two-year period, reports that *70% of the readers interviewed read the advertising in these businesspapers on purpose.*

There are many other equally important objectives. Companies must raise capital in order to be able to do the jobs that need doing for defense. Good community and employee relations are considered necessary to a company's well-being. These and other objectives have been effectively achieved by defense contractors through advertising.

The defense industry is made up of numerous private companies facing the tremendous challenge of meeting, in cooperation with the government, our national technological goals. To meet this challenge, the companies must be strong and healthy. To deprive them of the use of effective and honest advertising is shortsighted and wrong.

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—letters—

And 'Reverse Oidorites'

To the Editor:

Reference M/R, June 12, p. 15, to correct and clarify your definitions (of "meteorite" and "meteoroid"):

Meteoroids—while *outside* the earth's atmosphere.

Meteors—while *passing within the* earth's atmosphere.

Meteorites—*after striking* the earth's surface.

The *S-55* might be called a "reverse oidorite."

M/R is one of the few technical publications I *find* time to read thoroughly.

The "Astrolog" is especially well done and informative. Suggestion: In the column headed "Project" could you add a small *outline* drawing of the unit.

G. V. Plachy
F.R.A.S., Assoc. Fellow, A.A.S.

Mr. Plachy is of course correct regarding meteors, -oids and -ites. As for line drawings in the Astrolog, this is not feasible at present. We'll keep it in mind.—Ed.

Mostly Not Guilty

To the Editor:

I like your magazine in general and I was a charter subscriber. However, I cannot allow errors of the type on page 9 of M/R, July 10 (to) go unchastized (*sic*). Specifically, the errors in the items "Lunar Exploration Reshuffle" and "European 'Space Club' Set." In the first, you have used the adjective "quicker" instead of "more quickly." In the second, you have used "to participating" instead of "to participate." Also, on page 11, in an item headed "Marshall Set to Expand," you use "to over" instead of "to exceed."

While I realize that many changes have occurred since I studied grammar in grade school, I don't believe that today's teachers condone such barbaric grammar. Much has been written of the inability of the professional engineer and/or scientist to communicate with the laity. The examples cited above indicate that even prominent technical magazines should send their copyreaders to school.

Stanley V. Castner
The Marquardt Corporation
Van Nuys, Calif.

We feel only slightly chastised. Webster says "quick" and "quicker" are adjectives as well as adverbs. He also says that "over" has a legitimate meaning of "more than" or "exceeding" (we used "budget will double—to over $800 million . . ."). In the other item referred to, M/R reported that "West Germany has agreed in principle to participating in (the European joint space program)." According to the Library of Congress, it would have been correct to say "agreed . . . to participation in," in the intended sense of accepting the basic idea. The gerund form—"participating"—is a verbal noun. But we probably should have used "participation." Whew! —Ed.

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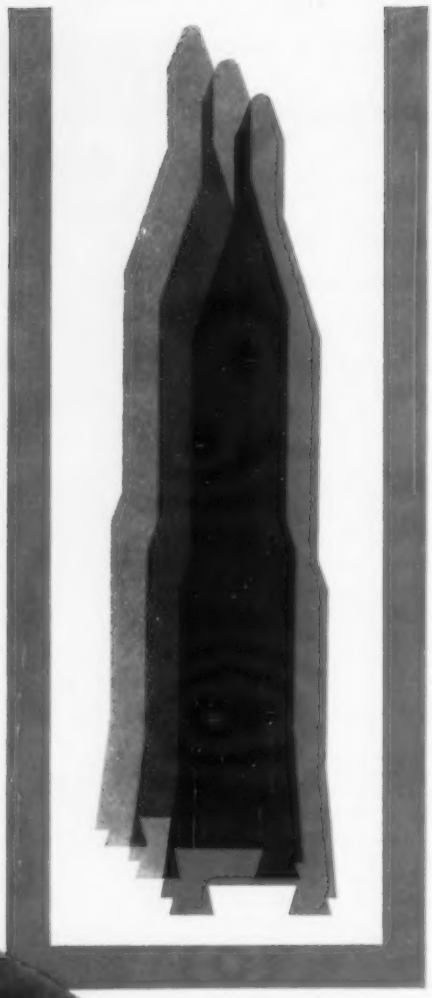

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The Countdown

WASHINGTON

NASA's Dilemma: How 'Big?'

NASA's top command is having second thoughts on just how "big" a man to put in charge of the *Apollo* man-to-the-moon program (M/R, July 17, p. 56). The dilemma: the program is certain to absorb most of NASA's annual budget in the years ahead. So any public personality picked to run the show is equally certain to overshadow the NASA top command itself.

Polaris Subs: No. 20 through 29

The Navy is understood to be ready to let contracts for construction of all 10 of the latest *Polaris* submarines planned by the Administration as soon as Congress passes the FY '62 appropriations bill. The submarines will bring to 29 the total number in the *Polaris* fleet commissioned or building. Latest price tag on a Polaris sub: $116.2 million—about $78 million for the submarine and $38 million for *Polaris* system equipment.

Polaris Bases: Pacific Division

Polaris submarines operating in the Pacific will load their missiles at Pearl Harbor and undergo overhaul at Puget Sound, Wash. The *Polaris* Depot at Pearl Harbor will be similar to the one near Charleston, S.C. The Navy long-range plans call for deploying two *Polaris* squadrons—18 submarines—in the Pacific.

Improved CBR Delivery Sought

The Army is quietly pumping more funds in FY '62 into developing improved means of delivering chemical and bacteriological warheads. Possibly as much as $100 million may have been set aside for developing drone carriers alone. The Army has expressed increased alarm over the Soviet buildup of CBR weapons.

ICBM Base Lessons Learned

Air Force officials feel that ingrown slippage in the ICBM base-building program has finally been brought under control. Although it is too late to make up much of the time lost to date, *Titan II* and *Minuteman* base construction are expected to move ahead on schedule thanks to much experience hard-won by the Air Force, Army, Industry and the Administration.

On the Pad

The Air Force is planning to fire its third *Minuteman* this week from the Cape. Also on tap: a *Blue Scout* and NASA's first *Ranger* lunar hard-landing vehicle tryout aboard an *Atlas*. A *Samos* is set to go from Point Arguello, Calif. (See p. 14.)

Who'll Go to the Moon?

It will be a year or two before NASA gets around to picking more astronauts for the *Apollo* program. The number will be increased to 40 or 50 above the seven picked for *Mercury*. Three-man *Apollo* crews are expected to include two pilot-engineers and a pilot-scientist in charge of the landing party to obtain samples of the lunar crust and other data.

INDUSTRY

Small Business for Ivan, Too?

Some military procurement officers are disturbed at new Kennedy Administration policies to give more defense work to small business. They feel that "anybody" can now obtain specs on many pieces of hardware. Says one official: "The 'contractor' might be a Russian agent, for all we know. He's not investigated until he returns a bid."

AF Overhauling Rocket Engines

The Air Force's San Bernardino Air Materiel Area, Norton AFB, Calif., has completed its first in-house overhaul of a *Thor* engine and shipped it back to England. The engine is the first of 400 programed for SBAMA overhaul through 1964. *Atlas* and *Jupiter* engines will come in from operational bases starting next month.

Proposed Solid Upper Stage

United Technology Corp. says its new fiberglass-cased solid rocket, if used as an upper stage, holds possibilities for increasing payload weight significantly. Performance of the 7 ft.-long, 18-in. motor containing 850 lbs. of propellant: I_{sp} in space—275; mass ratio—0.94; thrust—6000 lbs. for more than 30 sec.

R&D Intelligence

Astro-Rocket Inc. (Talley Industries Inc. subsidiary) has a process for casting rather than extruding ammonium nitrate for a new solid propellant. The low-energy, long-burning fuel will be used to actuate *Titan II* ICBM silo hatches. . . . AF has awarded Dynatech Corp. a contract for designing a 3000°F thermal conductivity measurement device to be used on super-alloys, honeycombs, cermets and ceramics.

INTERNATIONAL

Bloodhound Edges Out Hawk

COUNTDOWN hears the losing competitor in the Swiss deal for $84 million worth of Bristol/Ferranti *Bloodhound Mark II's* was the Raytheon *Hawk*. Sweden recently purchased about $66 million worth of *Bloodhounds*.

Overseas Pipeline

Expect the French Space Agency to set up a launch site on the French coast for sounding rockets. It is finding that it's too expensive to go to Colomb Bechar in North Africa every time it wants to make a shot. . . . Although the U.S. Army ordered Nord *Entac* antitank missiles with the idea that they were already in production, it's reported that the first production-line models won't be available until the end of the year. . . . West Germany expects to spend $400 million on defense procurement in the U.S. this year. In addition to $120 million for *Pershings*, it will be buying *Nike*, *Honest John* and *Sergeant* missiles as well as aircraft.

The Missile/Space Week

DOD Defines 'Selling'

The Pentagon for the first time has issued a comprehensive directive on military and civilian standards of conduct including a new, stiffer definition of "selling."

A spokesman for the team of DOD lawyers who wrote the directive said the guidelines stressed the need for as much clarity as possible within the confusing pattern of laws passed over the last century or more. The guidelines also emphasized that the tightest and strictest possible language was to be used.

The directive's key change defines "selling" to mean: "(1) signing a bid; proposal or contract; (2) negotiating a contract; or (3) settling disputes concerning performance of a contract; (4) any other liaison activity within a view toward the ultimate consummation of a sale even though the actual contract therefore is subsequently negotiated by another person. However, it is not the intent of this Directive to preclude a retired officer from accepting employment with private industry solely because his employer is a contractor with the Government."

Shots of the Week . . .

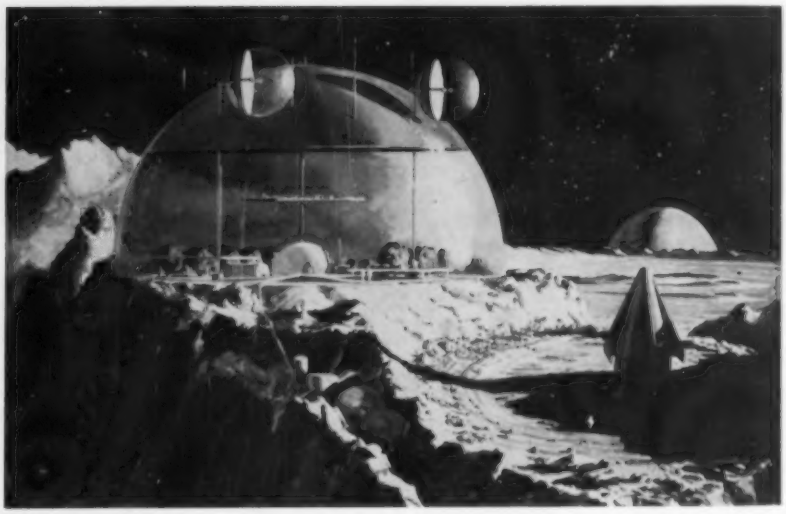
The Navy's advanced *Polaris* whizzed nearly 1600 miles down the Atlantic Missile Range July 14th, raising Navy hopes that the missile may be losing some of its temperament. It was steered by an all-inertial guidance system.

NASA fired three rockets from its Wallops Island facility. Two *Nike-Apache* sounding rockets were set off to determine altitude and intensity of electric currents in the ionosphere. A *Nike-Cajun* carried a 60-lb. payload including 12 grenades which were ejected and detonated at intervals from 23 to 56 miles altitude. All three shots were successful.

Biggest-yet Polaris Sub

The Navy's largest *Polaris*-firing submarine, Ethan Allen, joins the fleet early next month.

She is the first designed to fire the longer-range 1500-mile *Polaris*, has a length of 410 ft., weighs 6900 tons and will have gone from keel-laying to commissioning in less than 23 months. It was General Dynamic's Electric Boat Division.



Mountain Campsite on Moon

IDEAL LUNAR BASE SITE would be in the Mountains of Eternal Light near the moon's north pole, say North American scientists. The area would be in continuous sunlight, advantageous for solar power and plant growth. Dome at left is inflatable plastic. NAA experts are working on long-range lunar base requirements such as extracting necessary elements and compounds from the moon's surface.

Tiros III Aids Mercury

Information from *Tiros III* on Caribbean weather conditions affecting *Mercury* launch is being fed to the Cape. The data is analyzed by PMR or Wallops, sent to the Weather Bureau in Suitland, Md., then flashed to the *Mercury* Project Office in Florida. The satellite is programed for twice-a-day coverage.

Rickover — Abolish AF

Vice Adm. Hyman Rickover has proposed that Congress abolish the Air Force, saying it would probably reduce the cost of national defense.

In testimony before the House Appropriation's Subcommittee, he suggested combining SAC with the Navy and the AF's missiles with Army.

He said: "By returning to two services you will . . . eliminate some of your difficulties; you will be subjected to the same compelling arguments for appropriations from the two instead of three groups."

Free Spacecasting Favored

The U.S. communication satellite system should be open to all nations, including Red China and the USSR, USIA Chief Ed Murrow suggested to the House Space Committee. Said Murrow, "if we could freely transmit to Russia and China and they could freely transmit to us, I have no fear of the outcome."

Murrow also suggested an international space communications year, similar to the recent International

Ion Engine Capsules by RCA

RCA Astro-Electronics Div. has been selected to develop a payload capsule for flight-testing electric propulsion engines.

The program calls for seven capsules, three for ground tests and four for flight testing. First launch is scheduled for the last quarter of 1962 aboard a *Scout* rocket. The capsule will carry one cesium- and one mercury-fueled ion engine.

Flight testing is necessary in proving out feasibility of ion propulsion because the exhaust beam of an ion engine is influenced by the walls of even the largest feasible vacuum tanks.

Geophysical Year, "to prepare for the day when we will need qualified men from Conakry to Calcutta to help operate the satellite system."

Yuri Bypasses U.S.

Russia's peripatetic spaceman-goodwill ambassador, Yuri Gagarin, is due in Havana this week to help Castro's July 26th celebration get off the ground. He'll bypass the U.S. because "I have not received an official invition . . . So how can I go there without being invited?"

Earlier this month, NASA Administrator James E. Webb chided the Russians for sending their cosmonaut on a propaganda tour while not releasing pictures of his orbital flight. Webb said U.S. astronaut Alan Shepard's refusal to take publicity trips was his own decision, but that America may want to send spacemen on tour in the future.

While in England, Gagarin told a press conference his flight into space would "soon be followed by a second, a third and many, many more."

NASA Looks Over MacDill

NASA will send a survey team to MacDill AFB, Tampa, Fla., to check on its possible use as NASA headquarters, should Congress approve an increased appropriation for the space agency. Dr. Hugh Dryden said MacDill was one of the sites under consideration.

Meanwhile, Air Force Chief of Staff Curtis LeMay said that the AF was willing to share its MacDill facilities with NASA or, if NASA wanted to use the entire base, to speed up its phase-out program there.

Boost for Job Fairness

Eight large defense contractors have pledged themselves to a no-job-discrimination plan, approved by the government. The pact, affecting some 800,000 workers, is similar to the one signed some weeks ago between Lockheed and the President's Committee on Equal Employment Opportunity.

President Kennedy said that during the next several months similar agreements will be sought with other large employers with government contracts.

Signing the pledge were the presidents of Western Electric, Boeing, Douglas Aircraft, GE, Martin, North American Aviation, RCA and United Aircraft.

Powerful Radio Telescope

A radar telescope with a parabolic reflector 150 feet in diameter is being constructed under the auspices of Stanford University and the Stanford Research Institute for completion later this year.

Requiring a power supply of one million watts, the new telescope is the most powerful ever built to operate in the 20-60mc. frequency range. When completed the huge dish antenna will enable scientists to obtain more accurate measurements of cosmic distances, surface explorations of the moon and planets, ionization data on the sun and planets and information on interplanetary ionized gases and debris.

The radar telescope will be operated jointly by Stanford University's Radioscience Laboratory and the Research Institute's Communication and Propagation Laboratory, with support from the Air Force's Cambridge Research Laboratories.

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In Berlin war scare . . .

Build-up of Army Missiles?

Expected emergency muster of reservists would necessarily call for extra tactical missiles; Soviets have announced increased emphasis on rockets; LeMay seeks more bombers

by James Baar

Malinovsky

". . . all weapons of the Armed Forces are being converted to rocket equipment . . ."

LeMay

"Put your finger on the button and you are at war . . . leave it off and have peace."

THE ADMINISTRATION is expected to call for an emergency increase in the nation's limited war forces including a major boost in the procurement of tactical missiles.

The price tag generally mentioned, as President Kennedy prepared a television report to the nation and a new special budget message to Congress on the Berlin crisis, was $1 billion or more.

Key members of the Senate Appropriations Committee, which has been withholding action on the FY '62 defense appropriations bill to give the Administration time to prepare its new request, made clear that they would readily approve the additional money and probably considerably more. Other members of both the Senate and House made similar supporting statements.

The core of the President's new request—scheduled to be sent to Congress July 26—was expected to be a plan to call up large numbers of reserve troops. Implicit in any such plans is the need for sizeable procurement of modern Army weapons including tactical missiles.

In recent years, the Army's 14 partly understrength divisions have consistently lacked sufficient quantities of modern weapons, from rifles to *Redstones*. There are no large stockpiles merely awaiting distribution.

How much production lines can be expanded or speeded up to meet the coming Berlin crisis this fall was not immediately clear. However, some of the President's comments indicated that he may be looking considerably beyond Berlin. He told a news conference on July 19:

"I am making my judgment on what I consider to be the relative power balance between the Communist bloc and ourselves, the attitude which the Communist bloc is now taking and what possible needs we might have in protecting our commitments . . . We operate at the end of a long supply line and others in some cases operate at the end of a short supply line . . . We have commitments in Southeast Asia, we have commitments in Berlin, and we are being very vigorously challenged."

At another point he added: "We have to look forward to many challenges in the coming months and years."

• **The line-ups**—An understanding of this challenge can be gained by comparing the current strength of NATO and Soviet Bloc forces in the heart of Europe.

The Red Army is reported to have 22 divisions in East Germany. Six are armored, six mechanized infantry, 10 conventional infantry. The East Germans have seven more divisions. The Czechs have eight.

Confronting these forces on the other side of the Iron Curtain in West Germany are five U.S. divisions, 12 West German divisions, seven British brigades, one French division and a number of other U.S. units including three crack armored cavalry regiments. Even this force is smaller than it looks because five of the West German divisions are still building toward full strength.

Moreover, the imbalance grows as you move away from the heart of Europe. Behind the NATO forces are four Italian divisions in Italy and a few units elsewhere in Western Europe. Behind the Communist forces are 150 Red Army divisions, the majority of which are at full strength.

Sixty of the Red Army divisions are armored. The Russians have been producing tanks at the rate of about 5000 a year.

• **Red rockets grow**—Recently, the Russians have sought to make this imbalance on the ground even greater by placing much heavier emphasis on their rocket and nuclear forces. In a recent little-noted speech, Soviet Defense Minister Rodion Malinovsky announced the reorganization of Soviet Armed Forces around rocket-bearing units and independently-operating nuclear groups.

"It is a most important fact," he said, "that all weapons of the Armed

Forces are being converted to rocket equipment. Thus the rocket units and formations are becoming the basic fighting strength of all branches of the Armed Forces."

"The (Communist) party and Government have taken all measures to insure the growth of the striking and fire power of the Armed Forces," he declared.

Marshal Malinovsky also made clear that he expected any future war to invoke the use of nuclear weapons.

Significantly, the Marshal's speech was delivered at the same time that Soviet Premier Khrushchev was announcing a 3-billion-ruble increase in the Soviet defense budget. Some Soviet experts have estimated that this could mean an actual total increased Soviet defense spending of $12 to $15 billion (M/R, July 17). Others have estimated that the Russians may be increasing their defense spending by 68% in the next six months alone.

Deputy Defense Secretary Roswell Gilpatric insisted earlier this month that the Pentagon's latest review of the nation's defenses was "directed primarily at the preparedness measures which could be taken in the near future—in a matter of months—looking toward strengthening the posture of our conventional forces."

However, the calling up of reserves and the long-delayed increase of procurement of modern weapons for the Army could have a far-reaching effect on the overall strength of the nation's defenses. Also, there is mounting pressure in some sections of Congress for new overall increases, particularly involving bombers.

• **Missiles plus**—Gen. Curtis LeMay, Air Force Chief of Staff, renewed the Air Force plea in testimony before the Senate Defense Appropriations Subcommittee for $448 million for full development of the B-70 Mach 3 bomber instead of the $220 million bob-tailed program requested by the Administration.

LeMay also gave his personal nod to the $525 million that Congress seeks to press on the Administration to keep B-52 missile bombers in production.

"We want the missiles," LeMay growled, "but we must have a mixture of manned and unmanned systems for proper defense.

"If you have only missiles you have no flexibility. You put your finger on the button and you are at war, or leave it off the button and you have peace. You cannot threaten or make known your intentions to fight over an issue."

All indications were that Congress agreed with LeMay. By the end of the week, there were some signs that the Administration might be reaching the point where it might, too. ¤

NASA Adds to Weight Of Apollo Lunar Spacecraft

NASA DISCLOSED three important facts about the *Apollo* Man-to-the-Moon Program last week at a secret NASA-Industry Technical Conference:

—The *Apollo* spacecraft despite its ballistic shape will have to weigh about 20,000 to 25,000 pounds rather than the 15,000 to 20,000 previously anticipated.

—There appear to be no insurmountable technical obstacles to landing a manned spacecraft on the moon and returning it to earth.

—NASA still does not have a firm *Apollo* program in mind nor has any decision apparently been made as to the precise way that NASA will manage the multibillion-dollar drive for the moon.

Essentially NASA presented to the hundreds of Missile/Space Industry representatives who attended the closed-door three-day session a comprehensive look at the technical problems and potential solutions of the *Apollo* program as seen so far. However, there was no discussion of such matters as firm plans, schedules, costs or managerial organization.

The reaction was mixed.

Many representatives from firms on the fringes of the *Apollo* program found the sessions highly enlightening. But representatives more familiar with the program found little new. There also were complaints that the 32 papers which were read and which will be available later might just as well have been mailed in the first place.

As one engineer put it: "How much would the program have been advanced if the cost of bringing everyone here had been spent on it?"

• **The outlines**—The broad, tentative plan for the program as it was pieced together from the technical papers calls for a ballistic-shaped, 20,000-to-25,000-pound command spacecraft capable of manuevering sufficiently to make an earth-landing on the ground—not water as previously thought.

The spacecraft will have an L/D ratio of about .5. It may have flaps. It also may have one of a variety of landing devices that would have an L/D ratio of 4 to 6.

For the lunar-landing mission, the *Apollo* spacecraft may have to rendezvous in orbit with propulsion and other units. This will be a must if the *Saturn C-3* is used. However, it is still much too early for a determination of booster systems.

The NASA papers on the configuration of the spacecraft were based on the three now-completed studies made by Convair, GE and Martin as well as a fourth study made by NASA itself. The four configurations are generally similar.

However, NASA has consistently stressed that the three industry studies and its own will not prejudice the coming award of R&D contracts for the *Apollo* spacecraft.

Although nothing was formally said at the conference about the award of these contracts, reports persist that a bidders conference probably will be held sometime next month and that contract awards will be made about the first of the year.

• **Manning the helm**—One problem that could delay awarding contracts is managerial rather than technical. So far, NASA has not made clear precisely how it plans to run the *Apollo* program beyond the idea of appointing a super manager and staff within the agency's headquarters. NASA currently is looking for a man to fill the super manager job (M/R, July 17).

One of the managerial questions to be settled is whether NASA or some outside contractor will provide overall technical supervision of the diverse elements of the program.

NASA Administrator James Webb spoke at the *Apollo* Conference in only the broadest terms of working together and selling the *Apollo* program to the public as a team. However, at one point, he said that about 15% of the *Apollo* budget would be spent within NASA, the other 85% with outside contractors.

Even as he talked, the huge Man-to-the-Moon program cleared another hurdle in Congress. House-Senate conferees approved the re-revised $1.7 billion NASA authorization bill for FY '62.

The conferees made no change in the total amount in the bill, but they switched $10 million from construction funds to R&D on solid propulsion and electrical propulsion systems. The more-than-half-billion dollars for *Apollo* emerged untouched. ¤

Replacement for U-2 . . .

Samos May Eye USSR for Up to 1 Year

Air Force adds new unit and extra technicians to handle flood of photos; details of improvements in the system

by Frank G. McGuire

THE THIRD R&D *Samos* reconnaissance satellite is expected to scan Russia for up to a full year—yielding a deluge of photo data.

Launch of *Samos III* carrying a new long-life solar power system is due this week. It will be fired into polar orbit from Point Arguello, Calif.

In preparation for the shot—part of a stepped-up effort to get an intelligence replacement for the grounded U-2 operational as soon as possible—the Air Force has established a *Samos* data processing unit at Strategic Air Command headquarters, Offutt AFB, Neb. It also has increased the number of technicians in the photo analysis unit of its Satellite Test Center (STC) in Sunnyvale, Calif., to between 30 and 50.

The increase in manpower at the STC photo analysis unit, part of the 6594th Test Wing (Satellite), presages a great increase of raw data into the center and the group will go on a three-shift-per-day basis when the input begins.

The similar but smaller group at SAC headquarters will assist in target planning and other activities. Primary center for all data processing during the R&D phases of the program, however, will be at the STC.

Processing of the film itself is done by a highly automated system consisting of a number of stations. Known as "interrupted processing," the method involves development of the film only to a minimum extent, whereupon the partly-developed image is electronically scanned to determine the steps needed to get the utmost from the film. The scanner transmits information about the image into a computer which determines the remaining processing. Time of additional development, temperatures, solutions and other information is calculated, is programed automatically.

• **TV readout**—By this means, the absolute maximum potential of the film is realized, and USAF obtains optimum benefit from the satellite's capability.

A contract estimated at $20-$25 million between the Air Force and Thompson Ramo Wooldridge reportedly was curtailed last November for unexplained reasons. The contract was for a complete data processing system for *Samos* and was let by AF's Data Systems Project Office. The computer-operated setup was said to be "too specialized" for its application. There is no indication as to the Air Force's planned substitute for this equipment.

A television readout system will be used in the initial phases of the program, but later satellites may use both TV and recoverable-capsule techniques to return data to the ground stations. Presently, some data quality is lost due to propagation, and the criticality of the loss is dependent on the nature of the information. Losses in telemetry readings of pressure points, radio frequencies, or other electromagnetic radiation are a little less critical than actual photo data.

SATELLITE FLIGHT is monitored by Air Force and civilians at headquarters of 6594th Satellite Test Wing.

Ground commands are first used to turn the *Samos* cameras on as the payload passes over selected points on the globe, then to turn the equipment off in order to conserve power. Presently, magnetic tape storage is utilized to maintain data in the payload until readout is accomplished upon command of a ground station. These ground tracking and command stations include those at Kodiak, Alaska, New Boston, N.H., and Vandenberg AFB, Calif. In addition the station at Kaena Point, Hawaii, will support operations.

At the optimum point in the orbit, VHF antennas will extract stored data from the payload, re-record it on tape, which will then be flown to Moffett Field, near Sunnyvale, for transfer to STC. The VHF TLM-18 multi-channel FM/FM transmitter in the satellite verifies command functions, reads out critical vehicle functions and handles payload equipment data. A separate system is believed used for detailed photographic data.

Supplementally to the telemetry data transfer method, the Air Force expects to recover film capsules from some of the satellites. This would eliminate transmission losses and provide verification of marginal information.

Speculation on resolution of the photographic equipment credits the system with being able to identify a 10-ft.-diameter object from 300 miles altitude.

Another recent improvement was the doubling of STC's computer for *Samos* orbital cal-

REMOTE STATION at Kodiak Island, Alaska, is part of far-flung tracking and telemetry net for Samos, Discoverer and Midas.

culations from 8000 to 16,000 48-bit words.

• **Solar power system**—A major improvement in the operating life span of the *Samos* vehicles has been the inclusion of solar power units to lengthen the estimated three week life span of *Samos II* to at least six months and perhaps a year for future payloads. Orbital altitude of the vehicles will determine this to a large extent, since radiation could cut the solar cells life significantly.

The system was first checked out partially on *Midas II*, which had three sections of silicon cells, comprising 26 square feet, secured to the aft end of the *Agena B* vehicle. The test system may also have been used on *Samos II*. Output was about fifteen watts for the three fixed collectors. Performance of the test system was used to aid in design of movable, larger solar collection arrays for the operational vehicles.

The test system operated well over 5000 hours without noticeable degradation of the cell performance. The vehicle's commutator stopped functioning, but the ¾-watt transmitter continued blocking the assigned frequencies. The solar power system was never used on an *Agena A*.

Midas III, launched July 12 from Vandenberg AFB, was the first to use the large double-array system designed to track the sun. This satellite weighed 1500 lbs. less than its two predecessors, presumably because a large portion of battery weight was eliminated, along with other equipment.

The larger solar power system is designed to provide 300-500 watts average power to the payloads of both *Midas* and *Samos* vehicles, with a heat power of about one kw on the array. Minimum specified performance on the silicon cells is 8.8% operating efficiency, but the panels do better than this. Power output is approximately 6.6 watts per square foot, and the payload is designed to operate effectively on half the available power, in event of failure.

Although average power is 300-500 watts, superimposed peaks of over one kilowatt are expected.

• **Coating problem**—A number of protective material coverings for the arrays were tested, with the aim of reducing micrometeorite and other particle damage, reducing input of thermal radiation which would cut array efficiency, and allowing transmission of a maximum amount of useful solar energy. Arrays are covered with a six-mil layer of glass, and weight of the assembly is about 1.1 lb. per sq. ft.

Excessive damage by radiation in the environment of space may force a switch to the radiation-resistant N-P cells and heavier glass, instead of the present P-N cells with the lightweight glass.

Due to stabilization of the vehicle, relative to the earth's horizon, an ideal reference plane is established for the solar array's sun-tracking system. This equipment was located at the rear of the *Agena B* vehicle, while the payload is located in the nose. The orbital configuration is thus established as a "T," with the nose-down satellite extending its two solar collector arrays parallel to the earth's surface.

The collector array system is housed at the rear of the vehicle in a folded manner, and extended by stepper motors at the desired time. The degree to which the extension takes place is dependent upon the power requirement of the vehicle payload. Maximum extension is approximately eighteen feet, while the array is about five feet wide.

Each array has 36 sections, 14 in. x 17 in., providing power to a regulator, which governs recharging of nickel-cadmium secondary batteries. The individual sections contain 740 separate 1 x 2 cm. silicon cells, arranged in ten-cell modules and connected in parallel on Kovar strips to make up a single-array 28-volt collector element.

The design gives the thinnest mechanical structure possible, in order to allow large-area arrays and adequate heat conduction through the panel.

• **Tracking control of array**—A dual stepping-motor drive is used to move the array while sun-tracking is in progress, and operates through a differential gear assembly. The two stepper-motors, when rotating in opposite directions, move the array about its own axis, while rotation of the two motors in the same direction move the array about the vehicle axis.

Conventional sun-seeking sensors are utilized for tracking, and seasonal adjustments are made by ground command. ¤

Cape Due for $65 Million New Construction This Year

CAPE CANAVERAL—The Corps of Engineers is getting ready to let a contract for building a second *Saturn* launch complex—bringing to about $65 million new construction planned at the Cape for the remainder of the year.

The *Saturn* contract—estimated at $10 million—is expected to run to $17 million by the time the complex is fully instrumented. Other major projects:

—A second *Centaur* launch complex, estimated at $16 million.

—Conversion of a *Titan* pad by The Martin Co. to handle *Dyna-Soar*, estimated at $16 million.

—Various new facilities at Patrick AFB costing a total of $2.1 million.

—A *Polaris* checkout building, $1.8 million.

Another $5 million will be spent on a new ocean cable installation between Puerto Rico and Antigua, and $3.4 million for tracking facilities on Grand Bahama Island and Puerto Rico.

The new *Saturn* service tower will be 300 ft. tall, 10 ft. shorter than the first, but will have a bigger base. ¤

Shortcut studied . . .

Prospect Of Orbital Shot in 1961 Is Fading

by Hal Taylor

ASTRONAUT VIRGIL GRISSOM . . . he had to wait.

CAPE CANAVERAL—Chances of an American orbiting the globe this year are growing more remote. The flight is now almost certain to slip into 1962.

NASA officials here for the second *Mercury Redstone* ballistic shot are conceding that only a string of spectacular successes with *Mercury Atlases* could make a manned orbital spaceflight possible before Jan. 1.

The main reason: *Mercury Atlas* is slipping badly. The launching of *MA-4*—scheduled to go in mid-July—has now been put off until early September.

This became known during last week's preparations for Air Force Capt. Virgil I. Grissom's programed 287-mile flight with a 116-mile apogee aboard a *Redstone*. Scheduled originally for July 18, the flight was scrubbed that day and again on July 19 by bad weather. It was rescheduled for July 21.

Grissom spent 3½ hours in the capsule aboard the fueled missile on the 19th, waiting for a "window" in the cloudy skies. The launching was postponed on the previous day before the countdown reached the fueling time. Once the *Redstone* is fueled there is an automatic 48-hr. recycling period for de-fueling and drying the LOX tanks.

• **Risky shortcut**—Another reason for slippage in the *Mercury Atlas* orbital program is a NASA regulation requiring manned space vehicles to undergo a minimum of six weeks of pre-flight checking on the pad.

NASA officials are presently considering a calculated risk which could speed up the program. This involves scratching the second launch in the orbital schedule—*MA-5*—which would orbit a monkey three times around the earth. Instead, the *MA-6* manned orbital flight would follow shortly after the successful launch of *MA-4*.

This could move the time schedule for *MA-6* up to November or December. However, seasoned observers see such a move as only a remote possibility. Besides regarding it as a questionable technical approach, the space agency apparently is not ready to risk U.S. prestige on a program that has not been adequately tested.

There is one slim chance for culmination of Project *Mercury* in 1961. If *MA-4, 5,* and *6* are completely successful, space agency officials contend, it would then be possible for the U.S. to duplicate this year the April 12 flight of Soviet Air Force Maj. Yuri Gagarin.

"If we get hot with *MA-4*," said one top official, "an optimist might believe that we would make it by Christmas."

• **No backups**—Working against such a possibility, however, are these hard facts:

As of now there are no backup missiles available for the *Mercury* program. Six *Atlases* are at Cape Canaveral. One will be used for the *Ranger* lunar probe slated for July 28. Three are *Atlas E*-model ICBM's which will be launched in R&D shots. Another is for a *Centaur* missile which will be fired as part of its development program.

The last will be used by Project *Mercury* as a booster for *MA-4* and will be placed on its launch pad sometime this week.

The boosters for *MA-5* and *MA-6* are not in sight at the moment. Thus, if any of the *Mercury Atlases* should blow up, it would delay the whole program for at least one month.

There is only one *Atlas* pad equipped for *Mercury* launchings. Lengthy delays would result if it were extensively damaged in a booster malfunction. Even when a launch is successful, it takes about a week to clean up the pad before another booster can be placed on it.

The reliability of the *Atlas* itself is still a question, although top officials of NASA's Space Task Group state flatly that they have complete confidence in the big booster.

It is a matter of record, however, that two out of three *Mercury Atlas-D* launchings have been failures. *MA-1* failed in September, 1959, because of a weakness in the stop structure caused in mating the capsule. This problem was corrected in *MA-2*, launched successfully in a downrange ballistic flight in November, 1960.

MA-3, lifted from its pad in April 1, 1961, only to be destroyed by the range officer when a programer malfunctioned, sending the booster straight up into the air. Many *Atlases* have been launched in Air Force development programs and none ever developed the same autopilot weakness. Space agency officials feel that it is unlikely that it will happen again.

Critics have charged that NASA should have scheduled more firings of the *Atlas-D* model to certify its reliability. Government officials point out, however, that under the Eisenhower Administration—when the *Mercury* program began—not enough money was made available for purchases of needed *Atlases*. The big booster has to be ordered from its manufacturer, Convair Division of General Dynamics Corp., from 18 months to two years before delivery.

If the Grissom flight is successful, the *Mercury Redstone* shots probably will be discontinued. This might mean that Grissom's backup—40-year-old Marine Lt. Col. John H. Glenn—will be picked for the first orbital shot. ⌗

Military pledges . . .

More Work for Hard-hit Small Firms

by James Trainor

DETROIT—Military leaders are promising to pass out a much larger share of DOD contracts to small business in depressed areas.

The new policy will extend beyond just urging prime contractors to subcontract out more of their work.

Brig. Gen. Fred Thorlin, commander of the Army's Ordnance Tank-Automotive Command, told the third annual Michigan Aeronautics and Space Association conference last week a plan being instituted by the Army calls for:

—Procurement arbitrarily set aside for small business participation.

—Early breakout of those components which it is felt that small firms can produce.

—A greater effort to obtain drawings and specifications of "sole-source" items so that these items can be competitively procured from other firms, especially small business.

—Encouragement of large manufacturers to sub-contract with small companies.

—More emphasis placed on advance publicity of proposed procurements, especially contracts appropriate to small business. (In this regard, Thorlin urged prime contractors to use the Department of Commerce Synopsis—free of charge—to advertise for sub-contractors.)

Thorlin said the Army has a goal of increasing awards to small business by 10% in FY '62 over what was awarded in FY '60, and that the Army intended to meet that goal. Navy and Air Force officials also urged industry representatives at the conference to solicit more business from small firms.

• **Military Space**—Gen. Bernard A. Schriever, commander of the Air Force Systems Command, reiterated pleas for a greater military space role. To meet the challenges of space, Schriever said, two things are essential: full national awareness of the implications of space and more efficient program management. New organizations and new techniques are needed to replace the outmoded techniques of mass production.

The general hung up six goals that must be achieved in this decade:

—Large payloads orbited by 1965.

—A space navigation and maneuver capability.

—De-orbiting and landing of spacecraft.

—Capability to transport, support and utilize man in space.

—Rendezvous in space.

—Construction of manned and unmanned space stations.

Schriever's thesis of military space got an unexpected boost when NASA's Wernher von Braun told a banquet audience that "space superiority has replaced air superiority out there."

• **Industry speaks out**—During the four panel discussions on procurement planning of each of the three military services and NASA, industry leaders pointed out some of the deficiencies in procurement policies of the government.

The Navy received the first broadside when Dan Kimball of Aerojet questioned the wisdom of the constant rotation of officers in and out of Washington. Lockheed's Stanley Burris argued that, rather than giving industry detailed requirements for what the Navy thinks it needs, it should require industry to maintain high standards of quality and reliability. Burris said the Navy should apply the Soviet formula of "selective technology" to future planning to formulate procurement plans with industry and scientists for 10 years into the future.

B. M. Brown of Westinghouse voiced the sentiment that not only should a DOD contractor be able to earn additional profit from a job well-done, but a firm should be able to lose money for inefficiency as well.

Walter G. Bain of RCA outlined a program for future space agency contractual actions:

—Let industry know the future objectives of NASA.

—Give companies prompt authority to proceed after a contract award.

—Adequately fund those projects that are approved.

—After a contract is let, debrief companies so that they will know the deficiencies of their proposal.

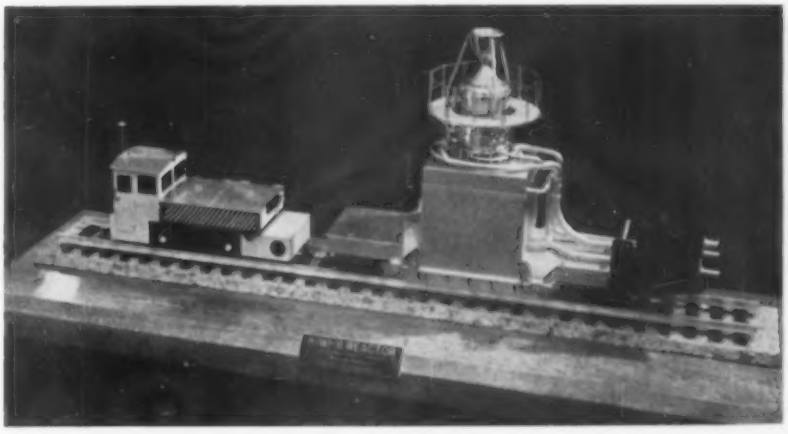
—Give industry a chance to compete for additional profits.

—Pay more than lip-service to fixed price and incentive contracts. Contracts that the government expects a company to take for the prestige involved, are hard to justify to the stockholder when he opens his dividend envelope. ⌗

New Look in Kiwi Reactors: Near-Flyable

SCALE MODEL of *Kiwi-B* nuclear reactor testbed for nuclear rocket shows closer attention to rocket-type exhaust nozzle, reactor pressure vessel reduced by about one-third over *Kiwi-A* series, and simplified ducting.

First hot run of the liquid-hydrogen-fueled engine is expected this fall, and although calculations and simulation indicate no difficulties with use of gaseous hydrogen, Los Alamos Scientific Laboratory spokesmen say the test should be "an interesting experiment." The reactor in *Kiwi-B* is a close approximation of a flyable reactor, and is now being assembled at Project *Rover* test area at the Atomic Energy Commission's Nevada Test Site.

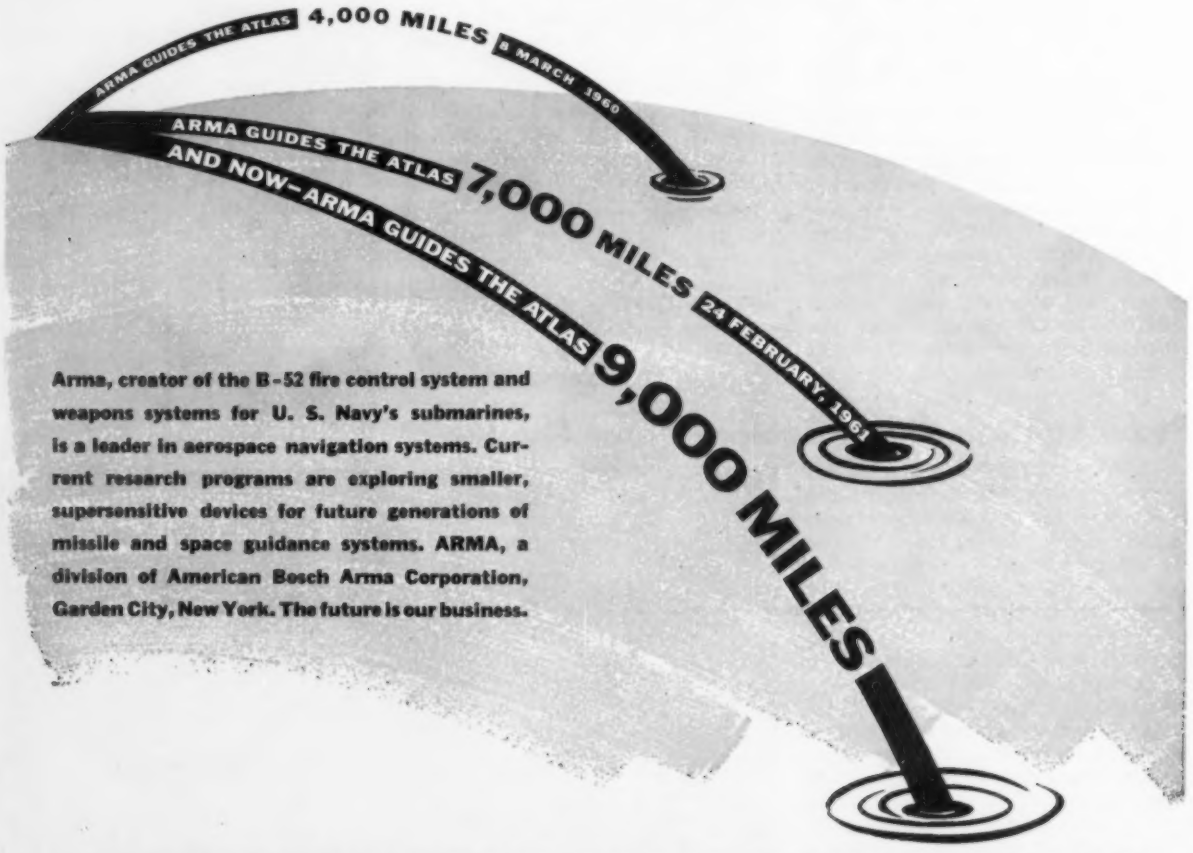


ARMA guides Air Force ATLAS in first full-range inertial flight

Cape Canaveral July 7, 1961. The Air Force announced the successful flight of an Atlas ICBM guided by the Arma inertial system 9,000 miles into the Indian Ocean.

A giant step in missile and space technology, this important feat of pin-pointing a target nearly half-way around the world demonstrated the phenomenal accuracy and reliability of Arma inertial guidance—America's first inertial guidance system of intercontinental range accuracy. This flight was another achievement of Arma inertial guidance which has performed successfully on every flight since the initial test in March 1960. Today the Arma system is in full production.

Arma inertial guidance provides our nation's ICBM arsenal with all the advantages inherent in inertial guidance—salvo firing, all-weather capability, immunity to outside interference, a minimum of costly ground equipment. Although specified for the Atlas missile, the Arma inertial system as a completely self-contained, self-correcting navigation system is adaptable to other aerospace programs and space exploration projects.



Arma, creator of the B-52 fire control system and weapons systems for U. S. Navy's submarines, is a leader in aerospace navigation systems. Current research programs are exploring smaller, supersensitive devices for future generations of missile and space guidance systems. ARMA, a division of American Bosch Arma Corporation, Garden City, New York. The future is our business.

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Technical Countdown

SUPPORT EQUIPMENT

Midas/Discoverer Tester Contract Awarded

RCA has just won a contract to supply operational simulation systems to test future *Discoverer* and *Midas* satellites. The award of more than $500,000 was made by Lockheed to RCA's Aerospace and Controls Division, for its Automatic Programer and Test System. This is believed to be the first system designed for automatic exercising of a major satellite's electronic subsystems in a space environment over a long time period.

Crystal-balling by Radar/Optics Studied

A study conducted by Armour Research Foundation for the Army Signal Corps indicates that meteorological profiles can be obtained up to 5000 feet by using a computer and radar and optical radiometers. A microwave radiometer—measuring oxygen emission in the 60-gigacycle region, and an infrared radiometer—measuring the emission from carbon dioxide in the 4.3-micron region, would feed their readings into a computer where the data would be converted into temperature-height profiles.

ASTRONAUTICS

UK Observatory Ready Soon

The new radio astronomy observatory at Defford, England, will soon be operational. Built for the Royal Radar Establishment by Woorkspoor N.V., Netherlands, the station will employ twin 82-ft. dishes. The 250-ton structures can be operated independently or dually to form an interferometer. In the latter mode, the system will permit very high angular discrimination. Operating in the 30-3000 mc range, the observatory will be used primarily for upper atmosphere and space research. A secondary effort will be made to study the causes of false radar echoes in missile early warning radars. Installation cost is expected to exceed £350,000.

British Instrument Launch Due by '62

Preparatory to launches by U.S. space vehicles later this year and next, the British will test-fly satellite instrumentation in their *Skylark* rocket at the Woomera Range in Australia. The instrumentation for the first satellite is designed to measure electrical charges in the ionosphere and cosmic ray particles. The second instrument package includes measurement of ozone concentrations, waves from electrons and micrometeorites bombarding the atmosphere.

U. of California Gets New Radio Telescope

A comparatively small, versatile radio telescope has been installed at the University of California as a gift from the Office of Naval Research. The 10-ft. dish is capable of intercepting much shorter wavelengths (4-8 mm) than those received by larger operational radio telescopes. The antenna —with a beam width of between one and two tenths of a degree—will be used to study such things as variations of solar activity on the sun, sunspots, solar flares, polarization of solar radiation, lunar radiation levels and planetary surface temperatures and chemical atmospheric compositions.

ASW AND SEABORNE SYSTEMS

Artemis Tackles Problem of Surveillance

Artemis—the Navy's program to determine the feasibility of very long-range undersea surveillance—has taken a step forward with the addition of a powerful sonar transducer and "advanced signal processing equipment" aboard the USS Mission Capistrano. The gigantic transducer—weighing hundreds of tons and consuming enough electricity for a town of 50,000—can be lowered into the sea for data gathering and recovered. A sister installation at Argus Island—30 miles southwest of Bermuda—is used in connection with hydrophones that relay sonar echoes to high-gain receivers.

New Sub Depth Gage Developed

A 3-5 times increase in measuring accuracy has been achieved with a new submarine depth gage developed by Westinghouse, the company reports. Capable of operating at depths five times greater than ever before, the new gage employs electrical measurement rather than mechanical (Bourdon tube) measurement used in conventional gages. Readout is by numerical meter instead of indicator dial.

MATERIALS

High-Flux Research Reactor Designed for NBS

A reactor to study basic structural properties of matter has been designed for the National Bureau of Standards' new Gaithersburg, Md., site. The high-flux device will be used to analyze atomic and molecular structure by neutron diffraction. In addition to its use in studies of crystal structure, intermolecular force constants and chemical bond strength, this powerful tool will have practical advantages in investigations of radiation processing and radiation effects on structural materials.

Space Flight Repair Pack

Engineers at Chance Vought and the Air Force's Aeronautical Systems Division are studying the problems of maintenance work in 3-D space under a $58,500 contract. A model of "back pack" is expected by next year. The study will determine how the pack can be used to give a weightless man control of his body while he makes repairs to operational space vehicles and satellites.

Dried Out Transistor Production

Precise moisture control techniques are resulting in power transistors with 3 to 4 db increased power gain and substantially reduced low-voltage saturation on several of Motorola's production lines. The ambient control system uses $BaO + CaSO_4 \cdot \frac{1}{2} H_2O$. Research is extending into germanium mesa transistors with equally good results.

Super Sniffer Developed

Westinghouse scientists have developed EGAD, an electronegative gas detector, which detects and measures gas concentrations as low as 1 part in 10 million. The device is currently being used to check out SF_6 leakage in high-voltage electrical apparatus, where the gas acts as an arc quencher. The unit possesses a 0.33-cu.-in. thermoelectric refrigerator which handles excess water vapor in the gas samples.

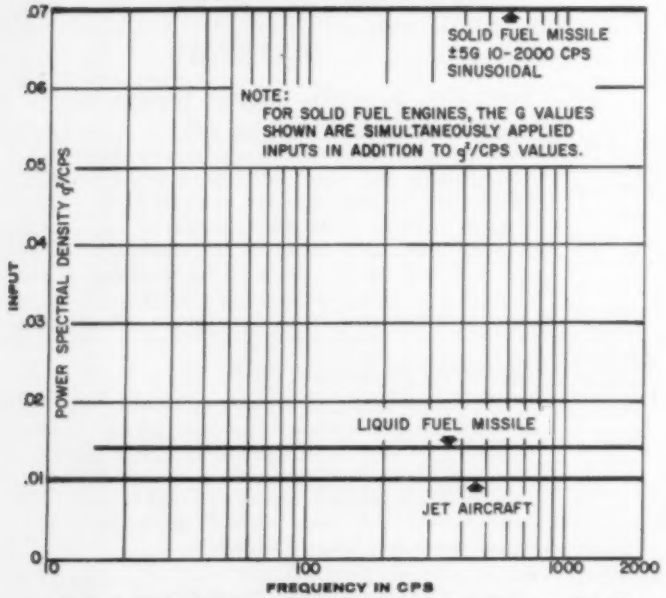
Isolation by Elastomeric Suspension

Atlas, Titan, Centaur are among programs whose inertial systems are protected from shock, vibration and noise by Lord-developed suspensions; a report on their advantages

by R. P. Thorn

Supervisor, Electronics Group
Product Engineering Department, Lord Manufacturing Co., Erie, Pa.

Typical Test Requirements



Characteristic Environments for Aerospace Craft

ENGINE VIBRATION	JET	LIQUID FUEL MISSILE	SOLID FUEL MISSILE
	PURE RANDOM EXCITATIONS		RANDOM WITH SUPERIMPOSED SINUSOIDAL EXCITATIONS
ACCELERATION	0-9 G	0-25G	0-25G
SHOCK	MIL-E-005272B PROC. II	15-100 G 5-11 MSEC.	40-100G 1-11 MSEC.
NOISE LEVEL	140db-160db	180db-200db	180db-200db
TEMPERATURE	MIL-E-005272B PROC. I	-100° TO 300°F	-100° TO 500°F
NON-DYNAMIC	MIL-E-005272B PROC. I	MIL-E-005272B PROC. I	MIL-E-005272B PROC. I

Fig. 1—*Comparison of test requirements and characteristic environments typically experienced by missiles and jet aircraft.*

ELASTOMERIC SUSPENSION is solving the problems of shock and vibration in advanced ICBM guidance systems.

Accuracy of both gimballed stabilized inertial platforms and strap-down inertial systems depends to a great degree on their ability to withstand mechanical disturbances.

Each is subject to unwanted responses of vibration, shock, and noise. The kind of isolation or suspension needed varies with the type of system. A highly specialized field, vibration control must be engineered into guidance system design during initial development.

Lord Manufacturing Company believes resilient or elastomeric suspension is superior to hard-mounting sensitive inertial elements because elastic characteristics at attaching points can be controlled with significantly greater precision.

• **Types of systems**—Inertial guidance systems may be divided into two basic types: (1) inertial or gimballed stable platforms and (2) body-mounted or strapdown systems. The function performed is the same for either type.

These systems are designed to guide a vehicle to its destination through a special form of dead reckoning which is independent of ground facilities. The starting point, desired flight trajectory and finish point are programed into the system's computer.

During flight, sensors in the system measure the dynamics of the vehicle, and feed this information to the computer. The computer then evolves displacement velocity and acceleration data which pinpoints vehicle position at any instant in time and space with respect to an accurately known starting point. This position is compared with the desired position, any error is sensed, and the computer signals the vehicle control system to make the correction.

Essentially, the inertial system incorporates two mechanical devices—the accelerometer group and the gyro system—which enable it to provide the navigation computer with accurate flight information. Within the accelerometer group, an accelerometer is aligned to receive dynamic inputs along each of three mutually perpendicular axes. The measured accelerations are doubly inte-

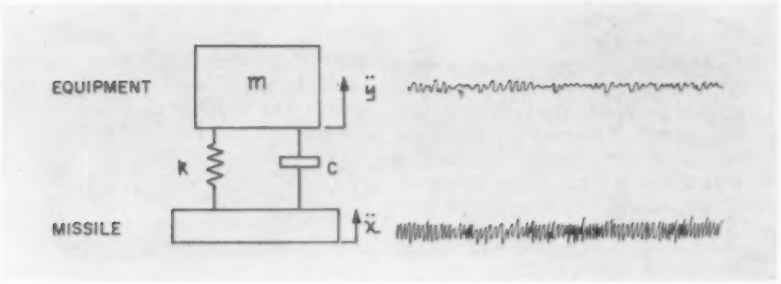


Fig. 2—*Typical trace showing effects of an elastomeric suspension system on random excitation. Random disturbances are effectively reduced between the vehicle and suspended equipment. Only a varying amplitude, narrow band of frequencies near the isolator resonant frequency is felt by the equipment.*

grated by the computer to arrive at the necessary displacement information.

In the stabilized platform, accelerometers are held in their original angular orientation by a three- or four-gimbal, servo-driven stable platform with three gyros. This provides instantaneous acceleration data along the three orthogonal axes of the original orientation.

Strapped down to the vehicle, the gyro system yields the necessary information concerning vehicle motion in inertial space. It merely acts as a transducer and, together with the strapped-down accelerometer group, is subjected to severe shock, vibration and acceleration environments.

Although the mechanical combinations used in both types of inertial navigators are simple in concept, they are exquisitely engineered and produced under ultra-sanitary controlled conditions. But since they are mechanical elements, they have natural frequencies and response characteristics that are functions of mass, spring rate and damping values for the distributed system.

The need for engineered protection is present wherever vibration, shock or noise produce unwanted responses. Accuracy depends, to a great extent, upon the ability of the inertial system to withstand mechanical disturbances. The kind of protection required will vary with the type of inertial system.

• **Low-frequency suspensions**—The stabilized inertial platform system—one which maintains a constant position in inertial space with respect to the starting point, but whose position may change with respect to the vehicular frame—usually requires a low-frequency suspension system because of its physical makeup.

The platform with its stabilizing system is large and massive. As a result, low structural frequencies are involved. The protective suspension must provide isolation efficiency compatible with the low-frequency response characteristics of the whole mass. (High-frequency control capabilities of the suspension are important in protecting individual components, such as accelerometers, which have extremely high resonant amplification.)

In addition this type of inertial navigator is fragile—again requiring a soft suspension for adequate protection. This suspension also must provide enough linear motion to accommodate both the vibratory disturbance and the sustained acceleration.

• **High-frequency suspensions**—The strapdown principle of inertial guidance, now emerging as a practical possibility as problems of computer size are overcome, presents a mounting problem entirely different from the stabilized platform problem.

The strapdown system has many of the same components as the inertial platform. Accelerations, however, are measured with respect to the vehicular coordinates—the three mutually perpendicular axes of the vehicle—and the whole vehicle is related back to the initial reference through a chain of mathematical calculations performed by a highly complex computer. The system must, of course, remain in a constant position with respect to the airframe.

Thus the suspension must provide a connection between the system and airframe that will protect the components, yet be stiff enough to prevent excess motion which could cause malfunction of the control system. This implies use of a center-of-gravity, high-frequency suspension.

Also, the portion of the strapdown system which corresponds to a stabilized inertial platform is smaller and less massive, hence more rugged, than the stabilized system. Therefore, higher frequencies are involved and a stiff suspension system may be used.

• **Range of disturbances**—Severe vibration, noise and sustained accelerations are the types of disturbances which combine to produce various dynamic environments for inertial reference systems.

When the art was young, specifications considered only sinusoidal vibratory disturbances and sustained accelerations. As more instrumentation data became available, it was found that random disturbances were more characteristic of the excitation produced by turbojet and liquid-fuel missile engines. This is an acoustical excitation which is transmitted through the structure and into the control compartment.

Solid-fuel engines introduce another component of excitation: a sinusoidal

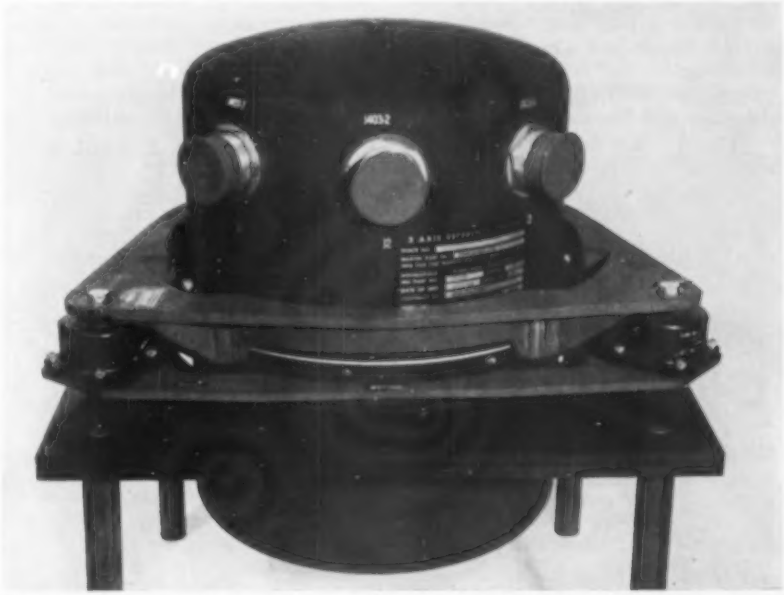


Fig. 3—*Three-point elastomeric suspension system solved degrading high-amplitude vibration problems experienced in Titan I 3-axis reference system.*

acoustical disturbance caused by resonant burning of the fuel in the cavity. It has a discrete frequency and is superimposed on the random excitation. These acoustical excitations will manifest themselves finally as structure-borne disturbances in the control compartment of the vehicle.

Thus there are two characteristic dynamic environments to be considered from an operational standpoint: (1) random, and (2) random plus superimposed sinusoidal. In each case, the equivalent sinusoidal disturbance required to duplicate damage resulting from random excitation may be substituted for test purposes. Superimposed sustained accelerations ranging from a fraction of one g up to 25 g must also be considered. (Typical test requirements and characteristic environments are shown in Fig. 1.)

• **Methods of protection**—Three techniques present themselves as possibilities for protecting an inertial guidance system.

First, the unit can be ruggedized, or made less responsive. This usually results in a weight increase which may degrade the overall performance of the vehicle.

Next, it may be possible to move the response characteristics of the unit out of the region of excitation. This is unlikely, however, in a missile or even a jet application, since it is difficult to build any mechanical structure with a natural frequency over 500 cps (a nominal frequency for this type of application). These excitations may range as high as 5000 cps.

The third alternative—flexible suspension of the unit—provides a method for avoiding degradation of performance while solving the protection problem. Such systems, using elastomeric mountings as flexible protective elements, have been proved successful on the *Atlas* and *Titan I* ICBM's, the *Polaris* IRBM, various unmanned drones and manned craft.

• **Elastomeric suspensions**—Essentially, the job of an inertial system suspension is to protect the system against the dynamic disturbances described here. Non-dynamic conditions covered by typical military requirements—sand, dust, fungus, and climatic conditions—usually are not factors in the system design analysis, because inertial systems operate in carefully controlled, air-conditioned environments and most available materials can meet environmental specifications.

The basic requirement, then, for a protective suspension is that it must have large linear capabilities to perform over the wide range of frequencies and sustained accelerations to which it is exposed. Further, the suspension must maintain its capacity for protection despite the static deflection resulting from the sustained accelerations.

Elastomeric materials are ideal in this type of application because they provide more energy storage capacity, hence greater linearity, than classical systems such as mechanical springs and damper combinations. Elastomers permit simplicity of design combining damping and elasticity in a single package which is compatible with tight-space applications. Resonant frequency control and superior attenuation of high frequencies are provided.

High-frequency characteristics are particularly important; this is the area in which troublesome structural resonances exist and high structural responses can occur in the inertial guidance system. Response characteristics of such components as solid castings, gimbal rings, rotors of the gyros, and accelerometers all combine to present a high-frequency problem far more severe than that of any other currently active application. High-frequency characteristics of a typical elastomeric suspension are shown in Fig. 2.

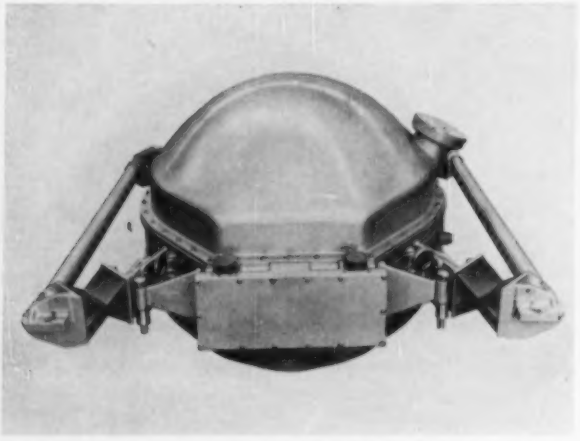
The best reason for choosing an elastomeric suspension instead of a hard mounting is that the elastic characteristics of the attachment points can be much more precisely controlled, both statically and dynamically, through resilient mountings than through a normal production structural configuration. The structural configuration presents the extremely difficult problem of driving each rivet or tightening each screw identically, plus controlling the interface of the mounting surfaces exactly.

It is a fact that flexible suspension of inertial guidance systems has become an acknowledged method of protection. For example, the original hard mounting configuration for the *Titan I* three-axis reference system built by Minneapolis-Honeywell did not prove feasible because of the system's sensitivity to high-amplitude vibration at certain frequencies. A three-point Lord elastomeric system was introduced and now provides the attenuation needed to protect the platform during the power phase of the flight (see Fig. 3).

Weight is another area in which elastomeric suspensions offer advantages. A suspension system design that is 10% of the supported weight has been considered exceptionally good. However, even better ratios than that are now being achieved. For example, the suspension system for the advanced *Atlas* inertial platform built by American Bosch Arma, weighs considerably less than 10% of the supported weight.

Properly engineered elastomeric systems do meet the requirements for minimum space and weight, and provide performance versatility necessary for control of both low- and high-frequency disturbances plus superimposed sustained accelerations.

• **Performance controls**—Effectiveness of an elastomeric suspension system is determined by the performance of



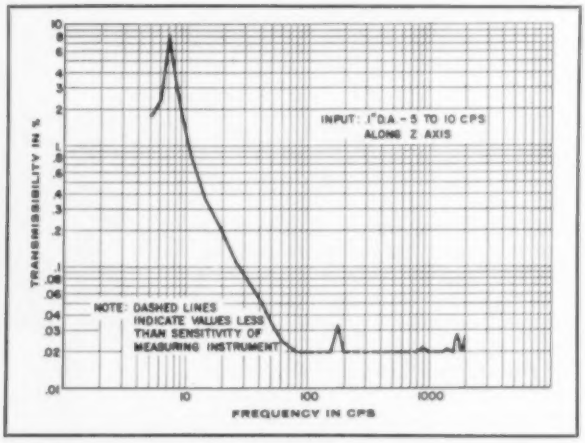
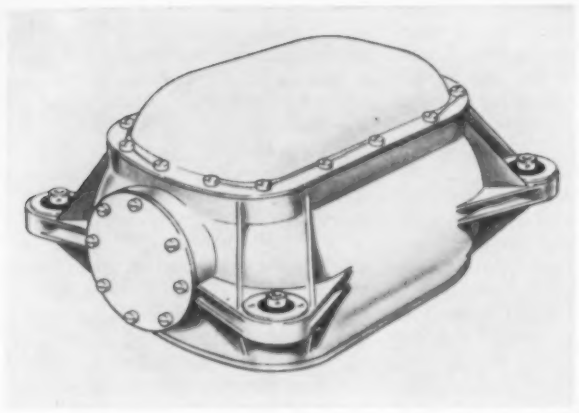

TRANSMISSIBILITY IN %
INPUT: 1" D.A. - 5 TO 10 CPS ALONG Z AXIS
NOTE: DASHED LINES INDICATE VALUES LESS THAN SENSITIVITY OF MEASURING INSTRUMENT
FREQUENCY IN CPS

Fig. 4—*Atlas all-inertial guidance platform and curve of typical transmissibility with the X-shaped rubber isolator system designed by Lord.*



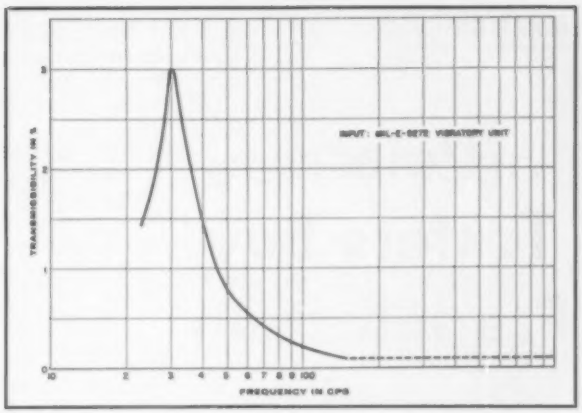


Fig. 5—*Drawing of Centaur inertial platform and transmissibility curve.*

each isolator in the system. Properties must be identical so that the characteristics of the system fall within the allowed tolerance. This does not necessarily imply customization of the elastomer.

Of primary importance are the methods of manufacture, testing and inspection. At Lord, ultimate system performance is controlled by matching each set of isolators dynamically as they go through the production facility. This is accomplished with a phase meter to measure the quadrature point of the relative motion across the isolator and the input excitation.

This method is used because the peak of the transmissibility curve on a highly-damped isolator is so broad that precise location of the exact peak value is not possible. But the slope of the phase curve is steep when passing through the 90° point and any slight deviation from the natural frequency of the isolator is noticeable.

The phase-meter technique, plus the use of a digital counter capable of five-place readings allows measurement of natural frequency to within plus or minus ⅛ cps. Each suspension system, then, is comprised of isolators whose natural frequencies fall within this tolerance.

• **Experience helps**—Inertial system suspensions now used in operational aerospace craft are deceptively simple in appearance. It is, of course, the purpose of the vibration engineer to achieve maximum design simplicity to meet space, weight and reliability requirements. Added to these considerations is the need for absolute protection within the dynamic environments described previously.

Protective suspension design is based on known or predicted vibration tolerance of the inertial guidance system. This is a matter either of testing the equipment, or of having the prior experience and thorough knowledge of the state of the art that make it possible to predict vibration tolerance.

Successful suspensions result when the vibration control specialist knows what is involved—in terms of missiles in general, in inertial guidance systems in particular—and can work closely with design engineers in the field to produce the required performance in the overall system.

• **Typical applications**—Design requirements for the *Atlas* all-inertial guidance platform called for an effective isolation system weighing less than 30 lbs., yet capable of supporting the comparatively heavy guidance package.

The final isolation system weighs about 10 lbs.

Arma performance specifications called for maximum transmissibility of 10:1 at input of 0.4-in. displacement amplitude along platform pitch, roll, and azimuth axes. Natural frequency was required to be in the range of 5.5 to 9 cps with an input of 0.4-in. displacement amplitude along each axis.

Lord designed a suspension system comprised of four X-shaped natural rubber isolators. These were symmetrically positioned around the inertial-platform center of gravity and connected by tubular cross members.

Final system performance characteristics were (see Fig. 4):

—Transmissibility: 6.5 to 8.5:1.

—Natural frequency: approx. 7 to 9 cps in each of the three major directions.

—Very high attenuation in the 120 cps region (natural frequency of string accelerometer).

For the Minneapolis-Honeywell miniature inertial platform used in *Centaur* and the Fairchild *SD-5* surveillance drone, Lord designed a system using four broad-temperature-range BTR Elastomeric Mountings. These were dynamically matched to ±⅛ cps and were symmetrically located about the platform CG (see Fig. 5).

M-H specifications called for a system capable of supporting its 28-lb. platform under accelerations up to 10 g and having an operational life of 2000 hours.

Besides meeting these and MIL spec requirements for vibration, shock, and non-dynamic environment, the final system successfully met five other M-H specifications:

1. Max. transmissibility of 3:1 at room temp.
2. Min. natural freq. (Final design was 28 to 32 cps.)
3. Returnability of ±3 min. under static conditions with 20 ft.-lbs. torque applied about any axis.
4. Dynamic misalignment: ±1.5 min. with 0-5G input and ±3 min. with 5-10G input.
5. Vibration envelope: max. motion 0.240 in. with sustained acceleration and vibration. ¤

AF Tests Use Wire Stretched 20,000 Ft. Up

A 20,000-FT.-LONG copper-clad wire was stretched into the atmosphere off the coast of Florida recently by means of an Aerocap balloon.

Part of an Air Force experiment to study long-distance, low-frequency, electromagnetic propagation, the wire served as an efficient 1-f antenna for the transmitting vessel below. The novel tests were conducted for Rome Air Development Center by Pickard & Burns, Inc., a subsidiary of Gorham Corporation, Needham, Mass.

A 120-ft. former pleasure schooner, "The Azara," was used to carry the wire, which was played out from a high-speed torque drum.

To charge the antenna, a 1-million volt generator was employed. The generator developed low-frequency pulses resembling natural lightning.

The Aerocap is a 90x30-ft. balloon, built and flown by General Mills, Inc., Minneapolis. ¤

Polaris Testers Buy Predetection Recording

Mincom system for raising volume of telemetry data retrieval wins Navy orders; Dynatronics, CEC producing another system for AMR use

LOS ANGELES—The Navy's first operational predetection recording system has been installed for use in the *Polaris* test program, indicating that the technique will be used increasingly throughout industry.

Predetection recording, designed to retrieve more data from telemetry transmissions, already has greatly enhanced data acquisition through modification, rather than replacement, of existing data retrieval systems.

The technique involves "taping" of a signal directly from an IF carrier, enabling test conductors to use the best detection method for processing each signal because the data is stored in a predetected state.

The system also has a high degree of immunity to tape dropouts; it can be used to simulate complete flights as a checkout for ground equipment. A number of duplicate tapes can be made from the original, with little degradation of data or signal-to-noise parameters.

• **First orders**—The Navy's first predetection recording system utilizes a CM-100 video band recorder/reproducer from Mincom Division of Minnesota Mining and Manufacturing Co. The C-100 takes telemetry data directly from the IF carrier by means of an antenna and a standard receiver using necessary converters.

Initial performance of the Mincom system impressed Lockheed and Navy officials and prompted further orders for the CM-100 setup.

A predetection system being developed by Dynatronics, Inc., and Consolidated Electrodynamics Corp. is expected to be delivered to the Atlantic Missile Range in November for a similar application. This system is unique in that it is the first to be designed specifically for predetection signals. It can simultaneously record both IF and video signals, and also record all types of telemetered signals. It is considered to be a completely new primary telemetry data recording system.

• **PDR technique**—A "typical" predetection recording method described by Mincom's C. S. Tobias consists of heterodyning the IF carrier of a receiver so that a new IF carrier and its sidebands fall within the passband of a recorder, and thus can be recorded and reproduced by use of magnetic tape.

Mincom says its CM-100 is the only currently available model which is completely phase-equalized across the entire passband, a desirable feature in predetection recording.

Predetection recording almost totally eliminates dropouts and their detrimental effects. Recovery of dropouts more than 15 db down is made possible because of the double limiting available through utilization of axis-crossing methods or counter-type discriminators for detection. Signal levels and amplitudes can therefore be widely varied without adversely affecting fidelity or accuracy of reproduced data.

Another advantage is the ease with which prime analog data tape can be copied without degrading the data. The reduction of quality in a normal analog tape makes it almost impossible to get an acceptable product after the third-generation copy, due to increasing phase distortion, ringing, overshoot, undershoot and noise.

Although signal-to-noise levels increase from copy to copy with the predetection recording method, the effects are not serious because the technique is not dependent on high signal-to-noise ratios and amplitude stability.

Mincom also points out that the IF from a specific flight can be recorded directly on magnetic tape, then used for flight simulation to check out ground equipment used in the system. The predetection recording technique can be used with any type of multiplexed FM signal — FM/FM, PCM/FM, PDM/FM, PAM/FM and even combinations like PACM/FM.

• **Steady base line**—Fidelity of the reproduced data is considered quite favorable, eliminating ringing, undershoot and overshoot from the detected video output data. In previously used systems, when data is recorded at one speed and played back on an analog recorder at reduced speed, a base line shift occurs. This is caused by a filtering effect from the low end cutoff point of the recorder amplifier.

(Continued on page 44)

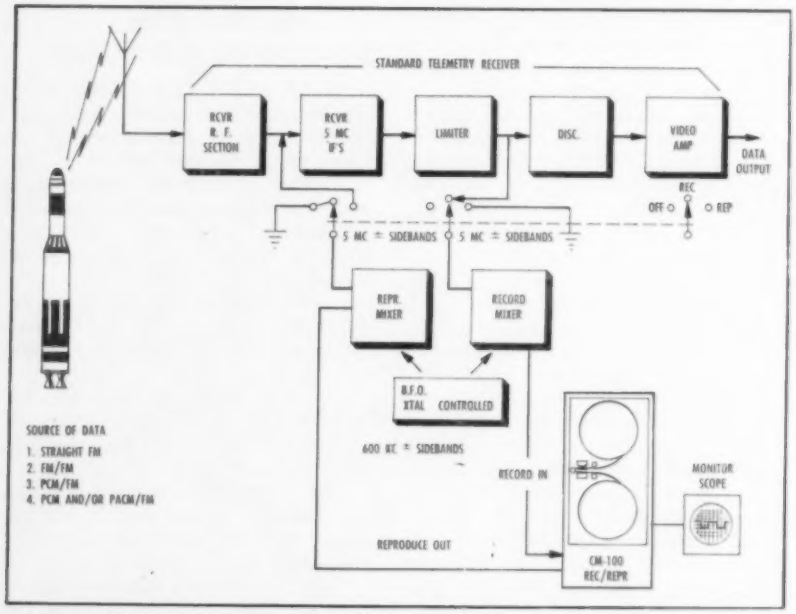


DIAGRAM OF OPERATIONAL PREDETECTION SYSTEM developed by Mincom.

Airmen Live 17 Days on Pure Oxygen

by Heather M. David

NO SERIOUS EFFECTS have thus far been found in the two Air Force captains who breathed almost 100% pure oxygen for 17 days at ⅓ sea level atmosphere in a recent School of Aviation Medicine test.

But SAM doctors report that the unusual environmental conditions produced some irritating effects on the lungs and breathing passages of the research subjects. And one of them lost 6 lbs.; the other 3 lbs.

The results are only preliminary. SAM spokesmen say that tests on the two men are still continuing, and similar experiments are planned for the future. Not until many more men are tested and observed for longer periods of time will space physicians decide whether they dare tamper with man's natural environment in designing space vehicles.

Purpose of the experiments is to determine how well potential astronauts can function in a synthesized environment. Because of the problems involved in duplicating a normal two-gas, sea-level atmosphere, U.S. spaceships may carry something less. The two existing life support systems designed for orbital vehicles—*Mercury* and *Discoverer* (animal)—are based on the 100% O_2, ⅓ atmosphere pressure specifications.

The test was the second of its type conducted at the School of Aviation Medicine. Last February, two other subjects were exposed to the same conditions on an exploratory, day-to-day basis.

• **Earlier results**—In the first test, SAM physiologists report, the two men had little or no change in pulse, breathing rates, blood pressure and body temperature. However, both men were weaker and showed decreased heart efficiency immediately after the simulated flight. They also lost weight and "may have become slightly dehydrated." The Air Force said these changes were similar to those which occur after decreased activity.

The Navy Missile Center at Point Mugu, Calif., also has been working in the same direction. Last week two petty officers completed a five-day test in which they breathed 100% oxygen at 34,000 ft. Preliminary results also showed no serious ill effects.

PREPARING FOR "SPACE"—Captains Westfall and Gang wear oxygen masks to flush nitrogen from their systems before going to altitude in SAM Space Cabin Simulator. Despite the precautions taken, both men reported some very minor "bends" during the 17 days spent in the cabin. No serious permanent effects were found.

The School of Aviation Medicine chose the 17-day period because this is the estimated length of time for a circumlunar mission using minimum energy.

Animal tests at the School also seem to indicate that a 100% oxygen, ⅓-atmosphere pressure can easily be tolerated for at least this time period.

The Air Force sees great advantages in a one-gas atmosphere, if it can be proved that man can withstand it for long periods of time without losing efficiency.

A great saving in launch weight can be effected if there is no need to add an inert gas (such as nitrogen) to attain sea-level pressure.

A knotty problem posed by a two-gas atmosphere is maintenance of the proper balance. Oxygen consumption by a one-, two- or even three-man crew would vary greatly during different times of the day. Special instrumentation and controls (at further weight and power cost) would be necessary to keep the balance.

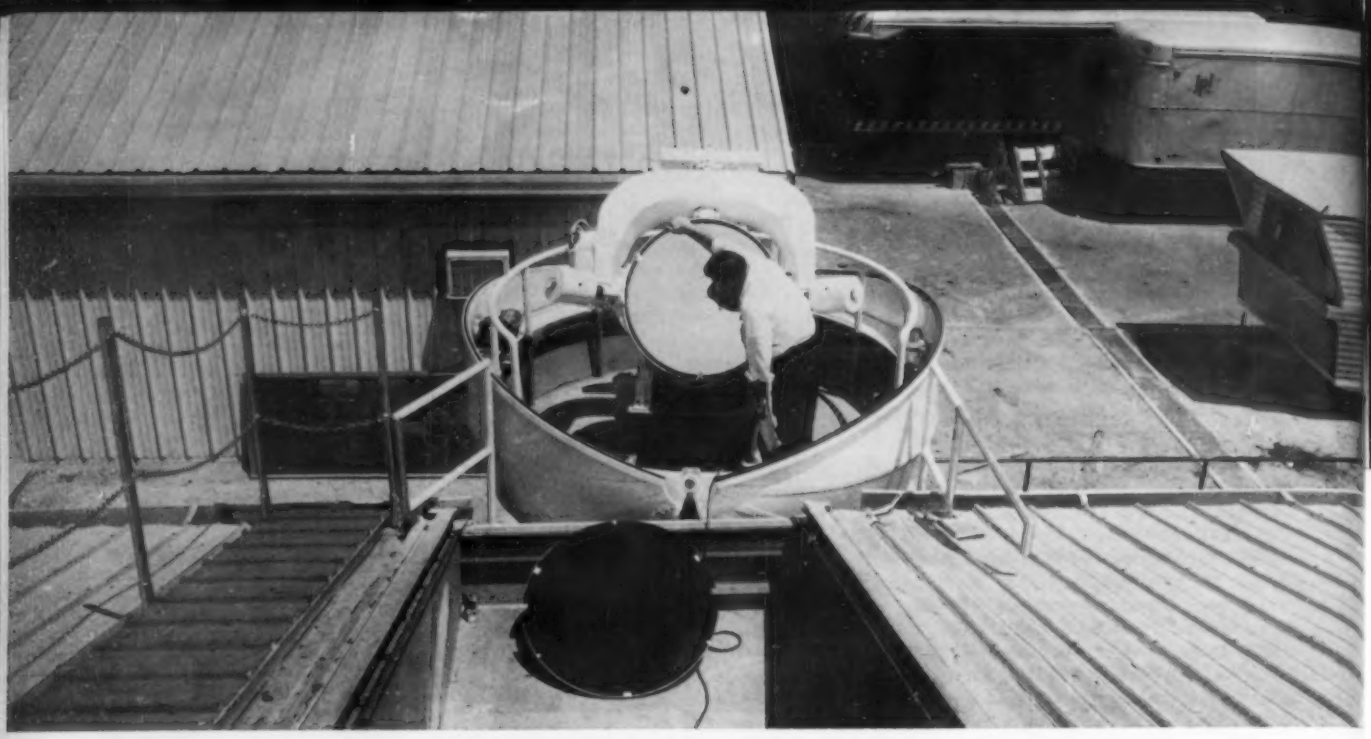
Dr. Hans G. Clamann, professor of biophysics at the School, pointed out in a paper recently that in a pure oxygen atmosphere, "a total-pressure monitor would be a minimally sufficient assessment of the oxygen available to the alveoli." This would greatly simplify the control system.

U.S. scientists already know that a high percentage of oxygen at sea-level pressure leads to severe damage to the lungs, breathing passages and brains—eventually leading to death. The ⅓-atmosphere pressure now appears to provide the correct partial pressure for breathing.

• **Other experiments**—The two Air Force captains also tested out a water recycling unit which was designed by the School.

Capts. Westfall and Gang spent four hours each day performing medical tests

(Continued on page 44)



test facilities

'Most Advanced' Celestial Simulator

JPL's half-million-dollar 'instant universe' will be used to test sensors of the Ranger, other moon vehicles

by John W. Herrick

PASADENA, CALIF.—Attitude control system sensors for the *Ranger* lunar impact vehicle will undergo test and evaluation soon on a new, $500,000 celestial simulator now in final checkout at Jet Propulsion Laboratory.

Other sensing devices—for *Surveyor, Prospector, Mariner* and *Voyager*—will be checked out later in the new facility, said to be the most advanced of its type in the world.

Designed and built, for the most part, by JPL personnel, the "instant universe" can duplicate white light and infrared point sources of solar system bodies likely to be used for navigation and attitude control of spacecraft—the sun, moon, stars and the earth. Both natural sunlight and artificial lights can be used.

Constructed inside a standard building at JPL, the simulator is housed in a 25-ft.-high dome with a totally nonreflecting interior. The 4 x 8 and 4 x 10-ft. structural panels have a specially treated inner face. The fitted panels were painted a dull black and covered with a thick layer of black felt. The final interior layer consists of 8-in.-thick honeycomb, also painted flat black. The end result is a laboratory interior with the total blackness of deep space.

The need for minimum reflectivity is pointed out by JPL scientists because test requirements will involve projection of an intense 3-ft.-diameter sun beam onto a test table while projecting a wall display simulating the earth and moon in the correct colors (as viewed from space) and at chosen phases.

• **Test area**—The basic simulator is a 1000-lb. test table supported just above the floor at the intersection of all light beams. Completely independent, the table rids on a 10-in. gas bearing (nitrogen) to provide three-axis, frictionless motion. This simulated spacecraft body duplicates dynamics of a spacecraft system using light sources as navigation and/or attitude control.

Except for a one-half-thousandth layer of nitrogen gas under the bearing, there is no contact with the building floor or the earth. A 28-channel telemetering system and a 28-channel radio command system link the table to a control room outside the dome. The table has a self-contained power supply of batteries and nitrogen bottles sufficient for full-day operation of table

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JPL SCIENTIST examines automatic motor-aimed mirror of heliostat that projects 3-ft., perfectly collimated beam of sunlight to second mirror above black-surfaced dome of the Celestial Simulator Facility within which NASA spacecraft sensors will be tested.

circuits, plus three attitude control jets for pitch, roll and yaw.

Because the perfectly balanced table operates in a gravity field, there is a slight mass shift when it tilts away from the bearing's vertical axis. This droop tendency under the 1-g force is compensated by automatic weight-shifting devices attached to the table.

Due to the gravity effect, actual spacecraft bodies will not be table-mounted. However, according to John R. Scull, chief of JPL's Spacecraft Control Section, all elements of a control system can be mounted in their correct relationship on the table and used to position the table as if it were moving through space or maneuvering to a selected plan.

The gas bearing is the clue to making a 1000-lb., box-like mass behave as if it were in space. For test purposes it is necessary to precisely maneuver around the bearing center at all operating attitudes a complex assembly of rate gyros, optical sensors, attitude jets, CG adjusters, power supplies and electronic units.

• **Blows off position**—Sensitivity of the test table was strikingly demonstrated to M/R. The unit was unbalanced simply by blowing a breath of average force against the outer frame. After a few seconds, a series of popping sounds indicated the table was rolling back to its original position under the low thrust of externally mounted attitude jets. The balancing operation was verified by control room instrumentation.

The two-in.-long positioning jets are sized to give the same thrust level and performance as future spacecraft supersonic nozzles will produce in space.

The bearing's 10-in. steel ball, produced by Bearing Specialities, is capable of holding maximum drift of the table to 5-millionths of an inch as it floats on a layer of 80 psi nitrogen. To hold this accuracy, JPL specified 10-millionths maximum deviation from spherical. This accuracy was achieved around one axis, but JPL expects to acquire a more perfect ball in the near future.

Test table inertia is such that, for the same torque, the system will exert the same acceleration as an actual spacecraft. Through a scaling relationship, space performance of flight-type sensors and instrumentation can be studied.

• **Switch to two rings**—Biggest JPL problem with the gas bearing was achieving proper balance with a single-orifice unit. Although unsymmetrical flow of gas around the bearing was only 0.5 standard cu. ft. per min. at atmospheric pressure, torques were induced on the table that the attitude control system could not handle. The flow also caused a somewhat inadequate lateral stability.

The current solution was to change the single-orifice, sonic-flow system to a bearing feed system having two concentric rings of multiple orifices at subsonic flow. An additional bonus was the "stiffening" effect on the bearing with two-ring flow. When the table is not in use or is in a fixed position, a Teflon sleeve lifts the ball off its base to prevent brinneling.

One of the facility's critical tasks is to correctly position light sources at a sufficient distance from table-mounted sensors to reduce focusing problems, and to simulate optical characteristics of certain "space beacons" with the correct color and luminosity.

The celestial simulator can place two accurate light targets anywhere on the dome's interior. Light source plates are held by two curved frames termed "planet source carriers." The carriers are propelled around a 40-ft.-diameter track on the dome's concrete floor by individual variable-speed electric drives.

The same drives, through mechanical linkage, raise or lower light sources along the carriers. Radial center of the moving carriers is the gas bearing which supports the test table. Upper pivot point is a circular track at the top of the dome interior.

PERFECT 10-IN. BALL of gas bearing permits spacecraft-simulating test table (shown here at extreme tilt) to rotate friction-free in any direction around center point of the Celestial Simulator dome.

At present, light sources will be positioned by static measurement techniques employing theodolites and similar instrumentation. In the future, the test table may be used as a calibration fixture, with signals generated by the table's rate gyros transmitted to the control room for remote correction of light source positions.

Provision has been made to modify the light source carriers at some future time to provide programed planetary motions, says Gerald S. Perkins, engineering specialist in charge of the celestial simulator.

• **Matching radiation**—JPL scientists have developed light sources which, with adjustable filters, simulate the earth, moon, or a specific star such as the South Pole Star, Canopus—required for *Surveyor* and *Mariner*. The systems are so designed that the intensity of tailored light reaching sensors on the test table equals radiation received on a spacecraft from a designated star deep in space.

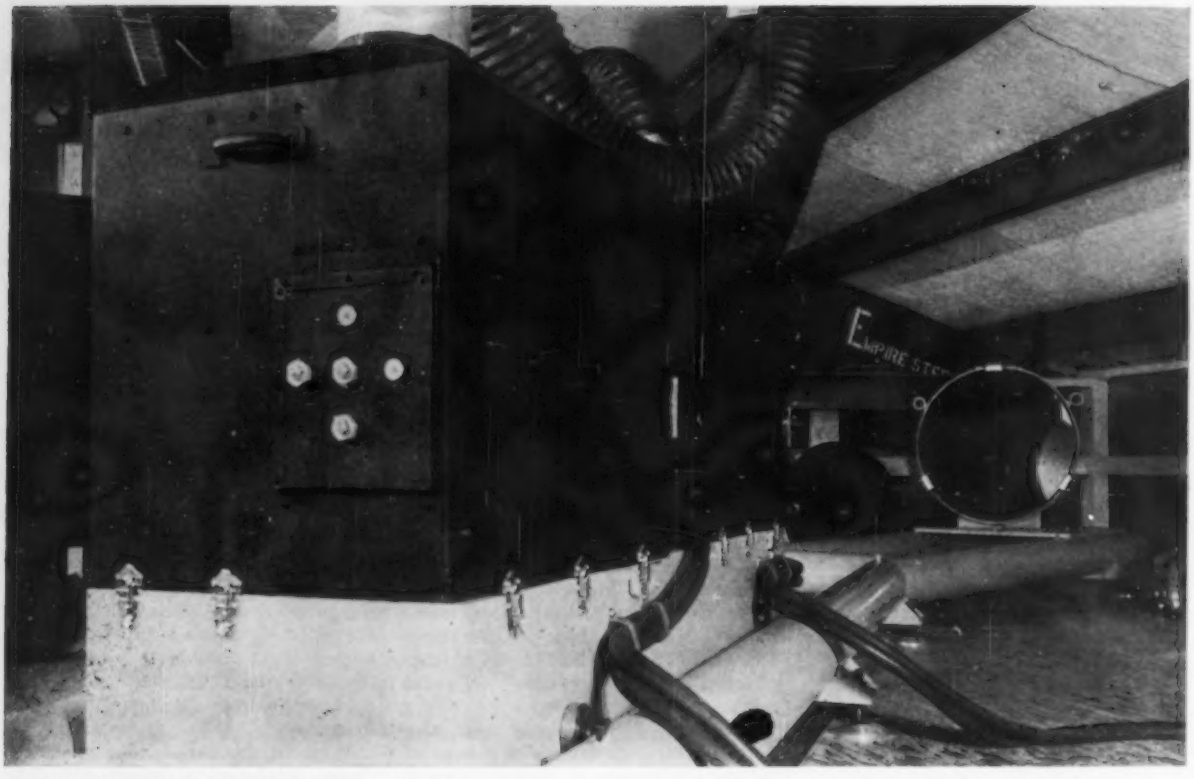
One of the lamps used for earth/moon simulation is made of a high-pressure mercury vapor and argon combination—similar to lamps used in Japan and Germany for motion picture projection.

Much work will be done with infrared sensors to study performance characteristics. In addition to natural sunlight, special JPL-produced IR sources that can simulate the earth's image from distances of 20,000 to 50,000,000 mi. will be held in place on the dome shell by one of the carriers.

Artificial sunlight sources are included in the "space planetarium." Scull said that tests of some components will require a more realistic simulation of the sun in space—particularly at the ultraviolet and infrared ends of the spectrum. In addition, special tests may require night-shift operations or heavy smog may interfere with normal daytime operations.

To provide the artificial sunlight, two heavy-duty arc-lights are supported on rails above the dome. The 225-ampere lights, used one at a time, throw an intense beam onto a corner-located mirror—ground off-axis—which reflects the beam into the central dome mirror.

Inspection mirrors ensure the arc is correctly positioned in the optical system. Anticipating a carbon life of about 40 minutes, scientists designed the arc lights for a quick shift of position, so the second lamp may be brought into the system when the other burns out.



ARTIFICIAL SUNLIGHT BEAM is produced for work area below in JPL's "space planetarium" by alternate-position arc-type lanterns. Note off-axis mirror (at right) to reflect beam over to central dome mirror, out of view. Inspection mirrors ensure that the arc is correctly positioned in the optical system. The lanterns are designed for quick shifting.

One other purpose of using artificial sunlight is to measure the critical distance between a spacecraft and a planet. By changing the arc-light aperture—inserting the correct lens in the optical system—operators can create the exact optical image of the sun at selected distances from Mars or Venus.

• **Unique heliostat**—One exception to simulation is the use of real sunlight. To capture solar radiation, JPL designed a heliostat claimed to be one of the most accurate in the U.S., with a reflected beam quality equal to that obtained by most observatories.

The heliostat, according to Perkins, is the only known installation with completely automatic mirror aiming. The sun beam, collimated within two seconds of arc, is reflected horizontally from the tower-supported heliostat through an opening in the roof of the building housing the simulator.

Accuracy of the motor-driven mirror aiming system is provided by a collimation sensor located in the opening, through which the rays are reflected into the dome by a second mirror above the dome's apex.

Thompson Optical ground both mirrors concave within two wavelengths of light to compensate for distortion by the sun's heat. After approximately 20 minutes of operation, both mirrors —of thickness 1/6 the diameter—are heated sufficiently to become optically flat. A motor-driven turret hood protects the heliostat against the weather when not in use.

The central mirror over the dome opening is fixed in elevation, but rotates manually in azimuth to receive light from the external heliostat or the nearby arc-lamp artificial source.

The celestial simulator will be used primarily for research in space optics, and also in support of the National Aeronautics and Space Administration —in particular to test the dynamics of automatic navigation and attitude systems based upon light sources and the accuracy in alignment a spacecraft will achieve when sighting on such targets. ⌘

Cover Story

Versatile Target Missile Tested

THE ARMY'S NA237 Redhead/Roadrunner is undergoing a series of test firings at New Mexico's White Sands Missile Range.

A ramjet-powered target missile, Redhead is built to operate at either high or low levels. It is capable of flying missions from 300 to 60,000 feet altitude and from subsonic speeds to a velocity of twice the speed of sound.

Built by North American Aviation, Redhead has a diameter of one foot and a length of 19 ft., with stubby triangular six-foot wings. Control is through small rear-mounted stabilizers.

The missile is equipped with an automatic parachute recovery system.

The target missile has been designed as a low-cost item. The Army plans to use it as a target for missile crews of the Army Air Defense Command. They will test-fire Hawk missiles at Redhead on low-level flights and Nike-Hercules on high-level runs.

In a successful test launching earlier this month, the missile was fired from a standard launcher under power of a 6000-lb.-thrust booster rocket. Within five seconds, it reached near sonic speed. Then the underslung booster fell away and the ramjet engine fired, pushing the target to supersonic speed.

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WARNING IS ALMOST INSTANTANEOUS. The sampling rate of G.E.'s Vapor Detector is approximately five times a second.

EQUIPMENT IS SIMPLE. Only a pump, sampling unit and alarm unit are required. All functions are fully automatic.

This vapor detector has already been selected by the Navy for a shipborne application, and can be tailored for any application where missiles or missile fuels are handled, stored or tested.

Here is another example of LMED leadership in aero/space electronics. 150-01

GENERAL ELECTRIC

Light Military Electronics Department

Utica, New York

Circle No. 2 on Subscriber Service Card

GE's New Cryogenic Gyros Near Testing

by Charles D. LaFond

FIRST VIEW of General Electric's new niobium rotor which will be used in an advanced cryogenic gyro now under development. The hollow sphere will next have the lips (top and bottom) removed and sphericity will be achieved to a tolerance of 10^{-5} inch.

CRYOGENIC GYROS that promise to increase guidance accuracy by several orders of magnitude are now nearing the testing stage.

Late this year, first advance versions will be tested at General Electric's Ordnance Department, Pittsfield, Mass., where they have been under development for the past two years. The work is now sponsored by the National Aeronautics and Space Administration's Marshall Space Flight Center, Huntsville, Ala.

Known as Project Spin, the cryogenic gyro concept was conceived at G.E.'s General Engineering Laboratory in Schenectady, N.Y., by Dr. T. A. Buchhold.

The study of superconducting metals had been in progress since 1949. As a fund of experience in handling and using materials at liquid helium temperatures was built up, Buchhold, an inertial guidance pioneer, envisioned a gyro design using these new techniques.

Here then was a new approach which might be able to offer a giant step upward in gyro accuracy and stability, with unheard-of reliability because of the absence of wear. Under a company-sponsored program, the cryo gyro was studied for well over a year. In time a cylindrical shell rotor within a cryogenic motor was built and operated at high speed. Buchhold's idea was conceptually proven.

The idea was sold to the Army Ballistic Missile Agency at Huntsville, and a contract for a prototype development was let in March, 1959.

By January, 1960, first results of the G.E. research effort were demonstrated at the opening of the company's new cryogenic laboratory in Schenectady. Rotor, motors, and non-mechanical bearings for the Mod 0 gyro were revealed for the first time.

During the next six months, all necessary components were built and tested. By late summer, the first gyro was completed and preliminary tests were started.

The goal was to drive the small spherical rotor at speeds up to 20,000 rpm inside a high vacuum and at temperatures down to −460°F (liquid helium).

Early laboratory tests had already proved the feasibility of suspending and rotating a metal body for very long periods in such an environment. But a multitude of questions remained to be answered.

First tests were not wholly successful. G.E. nevertheless feels it learned a great deal with its first units. Early gyro rotor tests never achieved speeds over 2000 rpm, because of undisclosed design problems. Cryo motors, however, were operated at 20,000 rpm.

Other major omissions in the early tests were the lack of test set-ups for measuring gyro drift or coast-down time. Since desired rotor speed was never obtained, such measurements would have been fruitless.

On the plus side, the gyro design principle was proven. That is, the rotor was suspended magnetically at cryogenic temperatures and it did spin under control at rates up to 2000 rpm. Also, for the first time super-conducting currents were developed by the transformers at these same operating temperatures.

Principal problem in the Mod 0 apparently was one of material. The Mod 0 rotor was a hollow titanium sphere coated with niobium. Also for proprietary reasons, G.E. has disclosed neither the specific problem encountered nor the extent of redesign for its new system.

However, in its new Mod 1 cryo gyro, it is known that the rotor will be a very precisely machined, hollow niobium sphere. The original stock will be an ingot of the purest quality niobium obtainable. Final size will be less than 2 inches in diameter and the rotor will weigh about 3.5 ounces.

Since true sphericity is a major characteristic of the finished rotor, it will be superfinished to a roundness tolerance of 10^{-5} inch. Concentricity of the sphere will be measured with the rotor at operating temperature (−460°F).

It is estimated by G.E. developers that the new rotor will be so nearly frictionless it should spin freely in operation for several months to possibly years after it is brought up to speed.

The new rotor fabrication is nearly complete. First test operation is scheduled for late 1961.

With its recently extended development contract, an additional $136,000 in funds was made available by NASA. This brings total funding to about $640,000—supplied by NASA, Advanced Research Projects Agency, Navy Special Projects Office and ABMA.

• **Superconductivity reviewed** — Electrical resistance in some metals approaches zero as the temperature environment nears absolute zero. So far, some 20 different metals and many compounds and alloys exhibit this tendency under such a condition.

The result is obvious: Electrical currents once initiated will flow forever in a superconductive circuit or until deliberately interrupted.

Resistance vs. temperature curves of the common metallic conductors are essentially linear. Near zero, but at some finite point, the resistance value be-

comes constant and the curve levels off.

However, some high-resistance metals, such as tin, lead, mercury, tantalum, niobium, and others, have the unusual property of attaining zero resistance when nearing absolute zero. They become superconductive. The change to superconductivity has been observed to occur very abruptly at temperatures below 10° K.

Superconductors exhibit other unusual but generally useful characteristics:

—Electric conduction occurs only at the surface, and the metal becomes diamagnetic.

—Current in a superconductive coil creates a magnetic field having a constant flux value.

—Up to some finite critical point, a superconductor acts as a magnetic-field insulator. That is, the field introduced induces permanent counter currents on the material surface which block or repel the field.

—A critical field intensity does exist, and causes the superconductor to become resistive. The critical value varies with each material and at different temperatures within the cryogenic range.

—Although losses are still extremely low, alternating currents at very high frequencies (over 10mc) experience some resistance in superconductors.

• **Motors tested**—Key concept in developing the very-low-drift-rate cryo gyro is its associated cryogenic motor.

Using superconducting magnetic bearings having high-load-carrying characteristics, the motors exhibit essentially no internal losses from either mechanical or electrical sources. In the laboratory, motors have been operated successfully using a superconducting rotor in liquid or gaseous helium or in high vacuums.

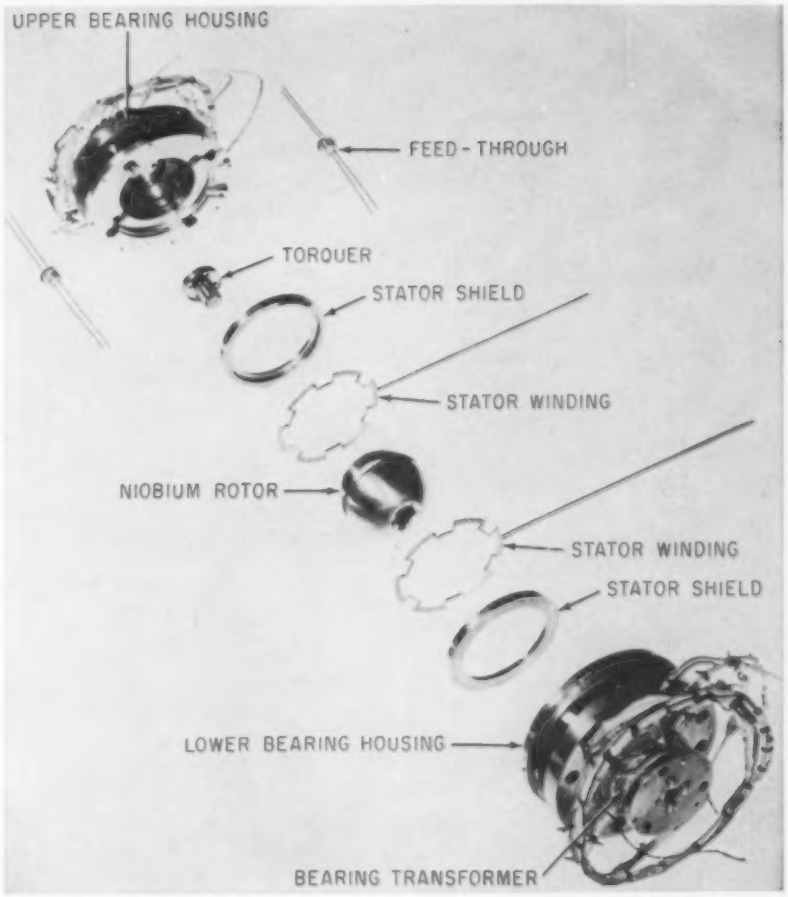
First proposed by G.E.'s Dr. Buchhold, motors were first used in the cryo gyro development program.

They employ niobium superconducting rotors, stationary current and stator field coils to lessen cooling problems.

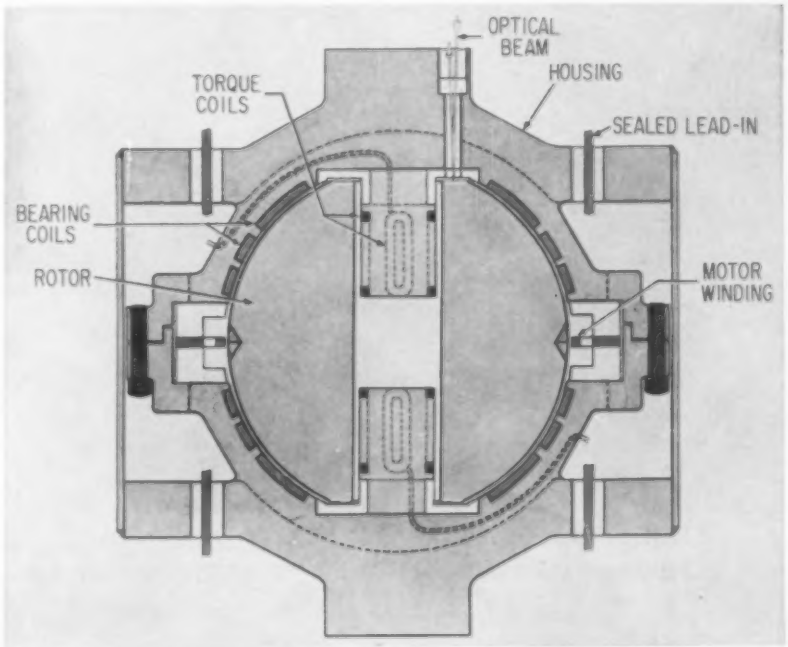
Motor bearings produce both radial and axial rotor support entirely free of mechanical contact with the rotor.

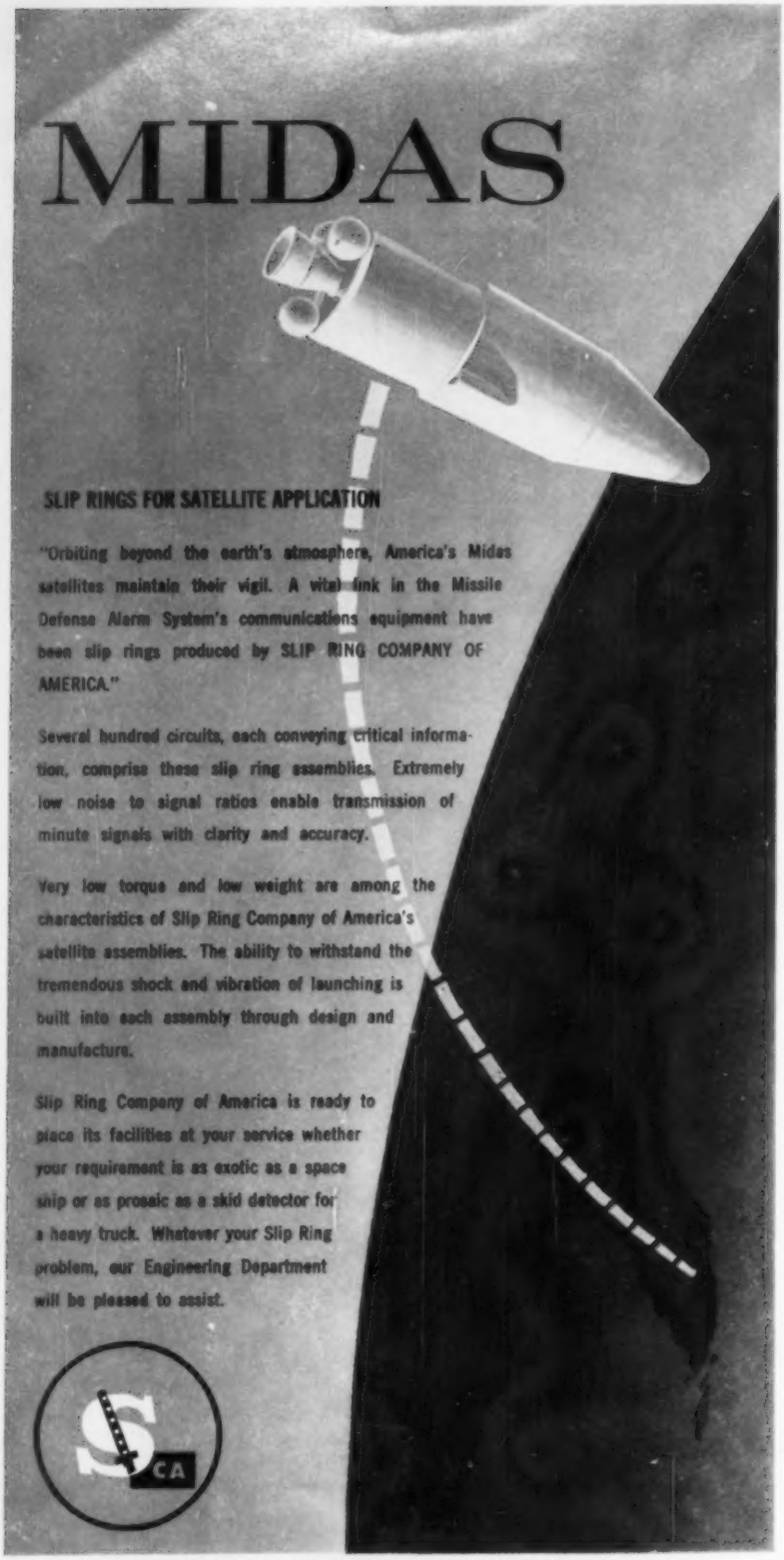
To develop rotor torques, symmetrically oriented grooves (or holes or slots) are machined around the rotor surface opposite stator windings. Torques are developed by both alternating and pulsed direct currents in the superconducting windings about the rotor. Magnetic forces normal to rotor-surface disfigurations produce the required operating torques.

Cryo motors have been operated in liquid helium at rotational speeds up to



EXPLODED VIEW (above) of G.E.'s earlier Mod 0 cryogenic gyro. Units achieved speeds up to 2000 rpm in laboratory tests, but redesigned Mod 1 gyro is expected to reach the desired 20,000 rpm not attainable with earlier version. Cutaway (below) shows assembled configuration.

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1200 rpm, and up to 20,000 rpm under a vacuum of 10^{-6} mm of mercury.

• **Accelerometers pushed**—Concurrent with G.E.'s gyro development is an expanding project to produce cryogenic accelerometers. A $120,000 development contract has just been awarded G.E. by Marshall Space Flight Center in an attempt to gain magnitude increases in accelerometer sensitivity and accuracy.

Units will be built, G.E. says, to operate at temperatures down to −452°F.

• **Broad future**—The real significance of the techniques and processes now being learned in cryogenics, G.E. feels, is their potential in other component areas.

Besides the obvious advantages in new inertial units for missiles and spacecraft, Dr. Buchhold believes we someday will see superconductivity employed in:

—Magnetic lenses for electron microscopes.

—Highly stable frequency and time standards.

—Microminiature switching units for shoebox-size computers.

—Super-accurate current-measuring standards.

—Noiseless and drift-free dc-ac amplifiers.

—And even ultra-high-current carrying power lines. (He indicated that lines envisioned would use half-inch cable carrying up to 10,000 amperes.) ¤

Sperry Hopes to Couple Light Modulator and Laser

A NEW light-beam modulator using a laser for a light source may some day supplant conventional microwave radar for many space applications.

This belief, held by Sperry Gyroscope Company, is based largely on the division's recent development of a device that modulates light at microwave frequencies.

Two advantages are achieved with the instrument, Sperry says: it is capable of considerably more accuracy than standard microwave radar—and requires much less power.

Such a system might be put to use early for space rendezvous guidance and space communications. In guidance, Sperry says, it would make possible a constant stream of precise position information between fast-moving or rapidly-closing spacecraft; in communications, a vastly increased amount of data could be transmitted with relative ease.

The device was developed at the division's infrared and optics laboratory in Great Neck, N.Y. ¤

Circle No. 5 on Subscriber Service Card

Novel Integral Nozzle Perfected

Haynes Stellite asserts capability in field of refractory metals, sees big aerospace markets

by John F. Judge

KOKOMO, IND.—An experimental tungsten-graphite integral rocket nozzle has been perfected by metallurgists at Haynes Stellite Co., division of Union Carbide.

Data derived from three tests by a major propulsion firm showed a complete lack of erosion and crack formation. Haynes spokesmen see no major problems in scaling up to flightweight nozzles with the technique.

Details of the nozzle were not disclosed, but the unit is not merely a tungsten liner with a graphite heat sink back-up. The nozzle is produced as a composite and machined as such. The graphite element eliminates hot spots and subsequent burn-through because of its thermal conductivity.

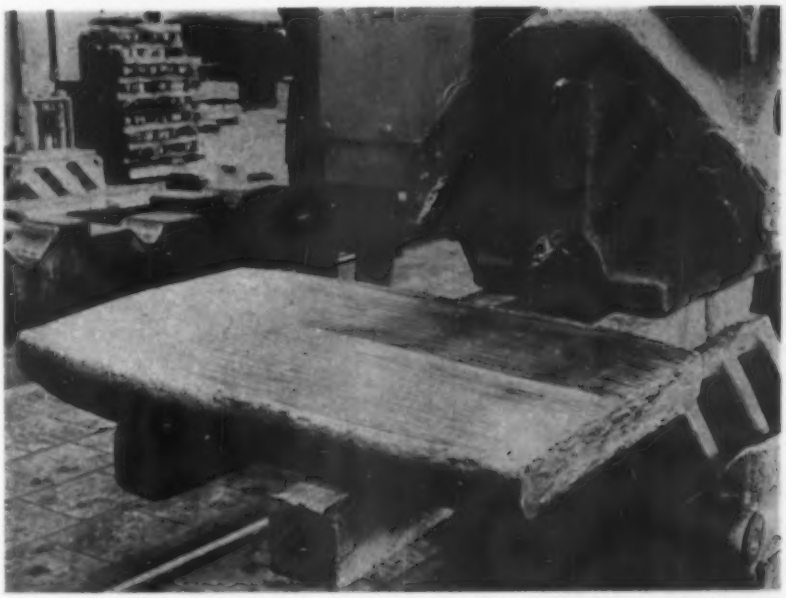
The nozzle shape posed a problem, as did the formation of a liquid interface between the tungsten and the graphite, but the firm found solutions.

• **Weldable Cb alloy**—In the refractory metals area, Haynes is producing a new high-strength columbium-base alloy. Designated Haynes alloy Cb-752, the composition is amenable to conventional fabrication methods and forms a ductile weld joint.

The material has an ultimate strength of over 25,000 psi at 4200°F. The alloy contains 10% tungsten and 5% zirconium and is available in sheets, plates and bars. It exhibits no heat embrittlement.

The firm also completed integrated and specialized facilities for the production of columbium, Nb 1% Zr, vanadium, tantalum and tungsten. Wrought forms of columbium, the columbium alloy and vanadium are available as production items, in addition to the wrought tantalum products and hot-pressed tungsten shapes in production for several years.

Part of the new capability is a 300 kw electron beam furnace built by Temescal. The unit has just started shakedown service. The productivity and economics of the furnace varies widely according to the particular material being melted and the extent to which it is free of volatile impurities.



FORGED SLAB OF PURE COLUMBIUM after cold-working from 6-in.-diameter round. Milling operations and cold-finishing Sendzimir will reduce it to thin sheet.

The furnace itself is tied in with other specialized equipment including a consumable electrode vacuum arc furnace, vacuum annealing facilities and a welding dry box. A 2000-ton forge press, standard sheet, plate and bar mills, a Sendzimir cold-finishing mill and wire drawing equipment are used in subsequent steps in the production of wrought refractory metals.

• **Confused market**—Haynes, like other refractory producers, finds it difficult to accurately define the overall refractory metal market. The firm approaches each segment separately.

The area is broken down further into a classical market and what is termed "new concepts." The classical product includes such things as tungsten filaments and the like. The new concepts market is primarily in the missile/space and nuclear areas. Haynes is interested in the latter.

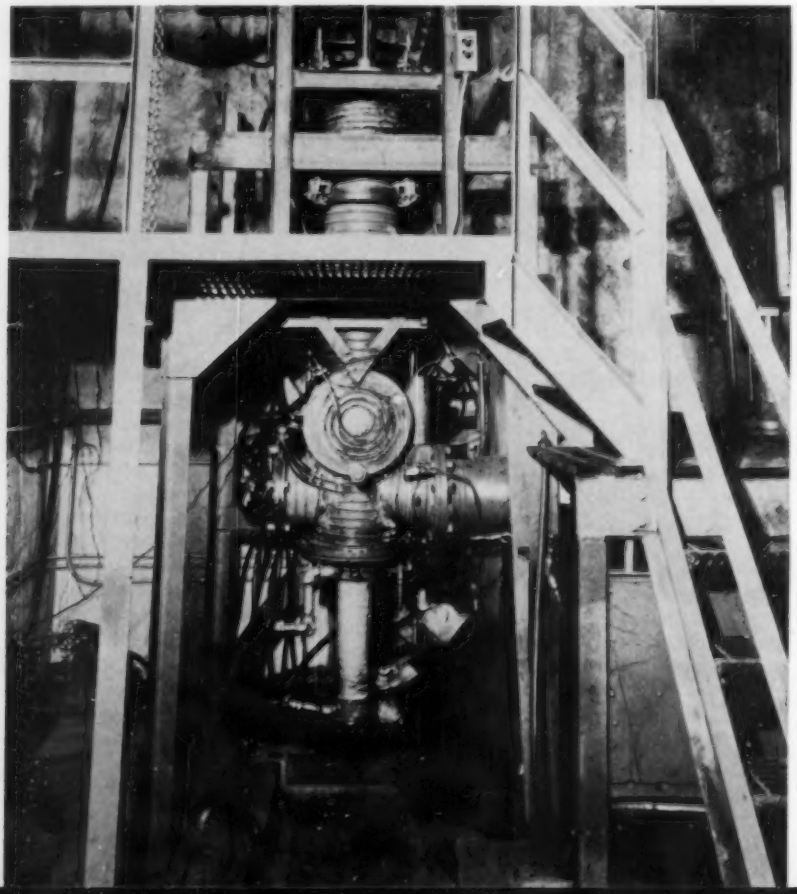
The firm does not depend on the refractory market. The same equipment, more or less, produces the tough Haynes alloys chiefly composed of cobalt, chromium, nickel, molybdenum and tungsten and used in aircraft engines.

Over 11 million lbs. of tungsten were produced by U.S. firms last year and around 300,000 lbs. went into various nuclear and rocket applications. Haynes feels there is a fairly well defined market in the rocket field for tungsten nozzles. The firm has been experimenting with the hot-pressing of tungsten alloys, tungsten carbide, tantalum carbide, hafnium carbide and 80 Ta– 20 HfC. The integrated nozzle is another application.

Haynes spokesmen see some movement towards columbium, especially as a backup for molybdenum in the high-temperature aerospace field. Columbium and its alloys fit in the picture as leading edges, skins, fasteners and structural components.

• **Oxidation headache**—The Union Carbide division has a capability in strip, sheet, rod and tubing forms in this family of alloys. The biggest stum-

ABOVE: *Electron beam furnace operation is closely monitored by an operator through a direct-vision window. Constant vigilance is maintained by trained observers throughout the entire melting cycle.* **BELOW:** *A view of Haynes consumable electrode vacuum arc furnace.*



bling block in the aerospace applications of columbium and its alloys is the oxidation problem. The full potential of these materials depends strongly on the development of adequate coatings.

A great deal of work is progressing in protective coatings around the country, most of it in government labs or government-supported. Haynes itself does not have any active program in the refractory protective coating area. The firm has placed its emphasis on taking the refractories out of the laboratory-curiosity stage and making them available in the sizes, quantities and forms needed by an advancing technology.

The oxidation hurdle is one of degree. Many applications have been found wherein short-term protection is sufficient—when the refractory metal performs its function before its useful life is over.

Haynes spokesmen say that vanadium seems to be gaining interest as a potential nuclear material. Columbium again may capture more of this market, particularly in fuel cladding applications.

Tantalum's big advantage is its inertness to most of the common corrosive media. The main market area seems to be in the chemical processing industries.

The refractory market, according to Haynes, is a specialty area. It is described in terms of individual applications and missions, and even these are in a state of flux. But the company is confident there will be a need for wrought refractories in the foreseeable future. ⁂

Space Flight Control Simulator Operational

An automatic controls evaluation simulator capable of duplicating control of a vehicle in space as close as possible is in operation at Chance Vought's Astronautics Division, Dallas.

The simulator, dubbed ACES, is an aluminum tubing platform measuring 12 ft. in length and weighing about 1350 lbs. The unit's base is a 4.5-in. steel ball supported on a column of nitrogen gas at 120 psi pressure.

ACES can rotate 35° in pitch or roll and twirl freely in yaw except when connected to the control console by wiring. It is equipped with eight reaction jets.

For manned operation, the platform has a seat, a side-mounted controller and foot pedals. An instrument package in front contains rate and attitude gyros and associated electronic equipment.

Detailed programs will include studies in electronic circuitry, sensors, fuel and power consumption, interaxis coupling and desaturation problems. ⁂

Vigilant Scores in 12 of 13 Shots

Antitank weapon shows rapid firing ability and accuracy in demonstration for NATO officers; sole miss due to rare wire malfunction

LONDON—Vickers *Vigilants* scored 12 hits out of 13 shots fired at Centurion tanks in the first public demonstration of the antitank missile.

The weapon, using dummy warheads, was shown earlier this month before high-ranking officers from France, Britain, the U.S. and other allied nations, plus the Russian military attaché. Vickers is trying to sell *Vigilant* to NATO countries and the British Army.

Earlier this year, it was demonstrated to leading NATO officers (M/R, June 12, p. 45). The British Aircraft Corp. says production can be in full swing within six months if they receive orders.

The 49-lb. weapon includes the missile itself (31 lbs. in flight), carry box (which also serves as launcher), pistol-grip control unit, vest-pocket battery and a drum of cable to connect carry-box and control unit. The whole is light enough to be carried on the back or dragged single-handed by a crawling man.

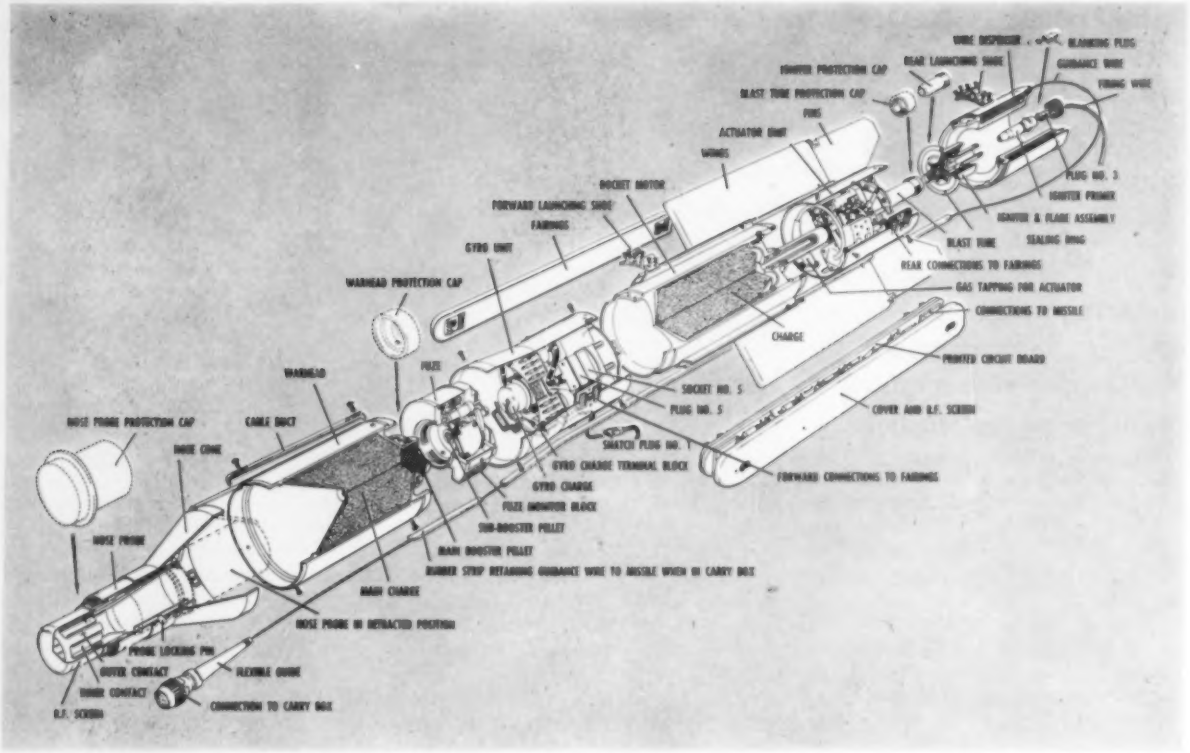
The missile is ready-armed in its box, and pre-firing preparations take only 30 seconds. The soldier snaps open the hinged lid of the box to prop up the box front (the missile is fired at an initial angle of 30° to clear the ground). He aligns the box in approximately the right direction and runs out the cable as far as he thinks necessary—maximum 75 yds.—but because the propellant is smokeless and there is no flash, the firing point is practically undetectable.

The firing sequence is simply to pull the trigger at the front of the grip and steer the missile into its target. A flare is burned inside the rocket exhaust; the infantryman guides the missile until the flare is superimposed on the target, and then keeps it there until impact. His control is a small box fitting over the thumb behind the pistol grip. Moving the thumb from side to side moves the missile from left to right, and moving the thumb backwards or forwards moves it up or down.

Signals from the control are sent along a wire paid out from an annular dispenser around the rocket exhaust. This contains about a mile of wire. A binocular sight is provided on the grip unit.

• **Angles of attack**—In the latest demonstration, at Warminster, 13 shots were fired by two men at four Centurion tanks presenting different targets. Twelve scored hits. The first six tests

VIGILANT takes off from launcher during demonstration. One round—even without warhead—punched a hole in tank's armored skirting.



EXPLODED DRAWING shows relatively simple construction of Vigilant.

were at individual targets approaching in different ways from a copse about a mile away and moving over "moon country"—rough chalky grassland studded with craters from previous artillery exercises. The tanks are able to travel at about 12-18 mph on this land.

These six tests resulted in hits at ranges of 1350 (in clump of trees), 1100, 1250, 1000 (target crossing, low down), 700 (head-on) and 400 yds. The last was designed to represent a short-range intruder appearing suddenly when the men were engaged with a long-range force.

In the final test at Warminster, four tanks approached simultaneously from different directions and the two infantrymen were told to fire as soon as they could see them. The two men hit all four in 48 sec.

• **Selling points**—The British Aircraft Corp. points out the following advantages of *Vigilant* over other anti-tank weapons:

1. Method of control. *Vigilant* has a closed-loop velocity control system; others use acceleration control. Velocity control brings the missile onto the correct course rapidly, increasing the chance of hitting the target at close range.

2. It is a one-man weapon. No "black box" is needed along the missile—all the innards are inside. *Vigilant* is readily portable.

3. It is in instant readiness. It can be set up in about a minute; after the button is pressed, it can be off in 30 sec. Hardly any power supply is needed—the operator has a vest pocket battery which is used to start the missile. After initial impulse, power is generated inside the missile by a turbogenerator running off the exhaust gases.

4. From a fixed position of the box-launcher (readily changed by hand), the *Vigilant* can be directed after firing at any target within an 80° angle.

A possible objection to *Vigilant* is its initial cost, twice that of its competitors. No figures are quoted by BAC, but cost is probably in the region of $1400 per round. ¤

Burner to Treat Titan Vapors

TOXIC VAPORS generated during *Titan II* fueling operations will be removed with a portable, high-capacity burner developed by Avien, Inc.

One of the major problems in the handling of storable propellants is the safe disposal of waste toxic vapors. The Avien Pyron system effectively treats these vapors, reducing the concentration of efflux into the atmosphere to bring it within the allowable limits defined by the American Conference of Governmental Industrial Hygienists.

The system consists of two burners, one each for fuel and oxidizer. The burners have a reactor and a control system, together with associated propane tank assemblies and vaporizing apparatus. The reactor is a horizontally mounted cylindrical stainless-steel furnace lined with firebrick and insulation.

Toxic vapors are fed directly into the burner from point of origin. An automatic flow sensor on the unit activates it when the flow surpasses a predetermined level. The vapors are detoxicated in the reactor, using propane gas. The system can be operated from its control panel or remotely, either automatically or manually.

Should a malfunction occur, the system immediately shuts itself off and indicates on the control panel the source of trouble. Thus, non-decontaminated vapors are never released.

The Pyron units can withstand shocks up to 20 g's. Input toxic flow rates may range from 2 to 440 SCFM. The system automatically compensates for the incoming vapor quantities.

The actual reaction process operates at lower temperatures than normally associated with this type of equipment. Besides conserving fuel, this avoids the problems associated with extremely high temperatures. ¤

names in the news

CONANT

SHORE

WEITZEN

HOLDAM

PROBST

Dr. F. Karl Willenbrock: Associate dean of engineering and applied physics at Harvard University, appointed senior consultant of the Sperry Rand Research Center to be dedicated later this year in Sudbury, Mass. Dr. Willenbrock will act as research director during the summer university recess and return to Harvard in the fall.

N. V. Petrou: Former engineering manager, appointed general manager of Westinghouse Electric Corp.'s Air Arm Division, Baltimore.

Frederick W. Conant, retired executive vice president of Douglas Aircraft Corp., and **Bertram N. Snow,** retired vice president of The Garrett Corp., elected to the board of directors of the recently-formed Titan Chemical Corp., Los Angeles.

Clifford H. Shumaker: Chairman of the Department of Industrial Engineering of Southern Methodist University, named president of The American Society of Mechanical Engineers.

David Shore: Appointed program manager for Radio Corporation of America's role in Project *Saint*. Shore formerly was associate director of Advanced Military System Group.

William Weitzen: Former Deputy Assistant Secretary of U.S. Air Force for Development, appointed regional vice president, Washington, D.C., Area Operations of Autometric Corp.

Dr. Lawrence L. Kavanau: Formerly manager of aerospace sciences in Space Systems Operations, Aeronutronic Division of Ford Motor Co., appointed Special Assistant for Space in the Office of the Director of Defense Research and Engineering, Department of Defense.

Dr. Kavanau has 15 years of experience in missile engineering, rarefied gas dynamics, heat transfer, hypersonics, experimental research, and research management and planning. At Aeronutronic, he had major responsibilities in the *Far Side, Shillelagh, Decoy* and *Blue Scout* programs.

Raymond Hamada: Former vice president of Telecomputing Corp. and general manager of its Whitaker Controls Division, joins Houston Fearless Corp., Beverly Hills, Calif., as senior vice president-operations.

Dr. Christopher J. B. Fincham: Promoted to technical director of Metals Division, National Research Corp., Cambridge, Mass.

Brig. Gen. Irving L. Branch: Former assistant chief of staff for nuclear systems development and chief of the Aircraft Nuclear Propulsion office, assigned to command Air Force Flight Test Center, Edwards AFB, Calif. **Maj. Gen. Robert H. Warren,** whom the Air Force previously announced would fill this assignment, has been assigned as commander, Air Force Systems Command, Air Proving Command Center, Eglin AFB, Fla.

Arnold K. Weber: Former director of manufacturing, promoted to staff vice president-manufacturing, Radio Corporation of America, New York City. **John H. Sidebottom:** former administrator, marketing staff, appointed division vice president, defense marketing, RCA.

J. V. Holdam: Elected vice president of Dresser Industries, Inc., Dallas, Tex. Prior to joining Dresser, Holdam was a vice president of Laboratory for Electronics.

Dr. James A. Fay: Professor of mechanical engineering at Massachusetts Institute of Technology, will spend a year's leave of absence as a principal research engineer at Avco-Everett Research Laboratory.

James B. Edson: Formerly with Missiles and Space Division, Raytheon Co., joins the Instrumentation Section, Aerospace Research, Inc., Cambridge, Mass.

Alan B. Dallas: Appointed director of field engineering, Consolidated Systems Corp., Monrovia, Calif. Formerly Dallas was regional manager for Minneapolis-Honeywell's Military Products Group.

Frank R. Herud: Formerly with Rockets Division of Textron Co., appointed manager of rockets marketing for Bell Aerosystems Co., Buffalo, N.Y.

Stanley E. Benson: Former systems staff manager, Military Products Division, appointed manager of long-range planning, General Dynamics/Electronics' Marketing Division, Rochester, N.Y. **Charles R. Green:** Formerly with Admiral Corp., appointed chief engineer of the Communications Laboratory in GD/Electronics' Military Products Division.

John R. Kimberly: Chairman of the board of directors of Kimberly-Clark Corp., elected a director of Corning Glass Works, New York City.

David L. Anthony: Named manager of component production, U. S. Sonics Corp., Cambridge, Mass.

Edward P. Farnsworth: Named senior staff engineer, Advanced Sciences Division, Laboratory for Electronics, Inc., Boston, Mass. Before joining LFE, Farnsworth was project engineer at Raytheon's Missile and Space Division.

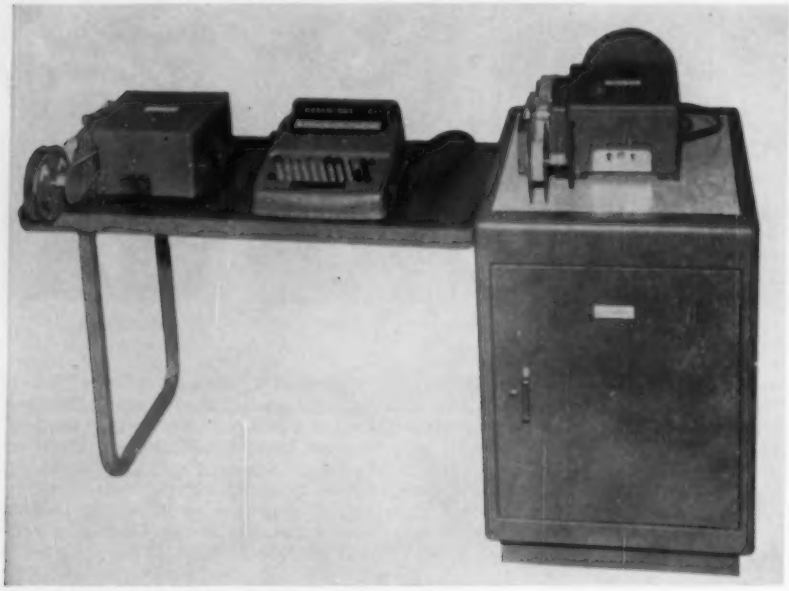
C. Daniel May, Jr.: Joins the Communications Systems Center of International Business Machines' Federal Systems Division, Rockville, Md. Formerly May was chief civilian manager of the Defense Communications Agency's directorate of operations, Department of Defense.

James C. Callaghan: Appointed manager of the Operations Staff, Space Systems Operations, Aeronutronic Division of Ford Motor Co. **Phillips Eastman, Jr.,** succeeds Callaghan as manager of the organization planning department.

M. Clayton Burgy: Program manager at Hercules Powder Co.'s Bacchus Plant, named manager of contracts administration in the Chemical Propulsion Division of the company's Explosives Dept.

Gerald G. Probst: Former chief of radio-inertial division of guidance and control development, AF Ballistic Systems Division, Los Angeles, joins the staff of the chief engineer at Univac, St. Paul, Minn.

Dr. L. Curtis Foster: Former director of research, elected vice president, Zenith Radio Research Corp., Menlo Park, Calif., a subsidiary of Zenith Radio Corp.



Code Tape Punch/Verifier

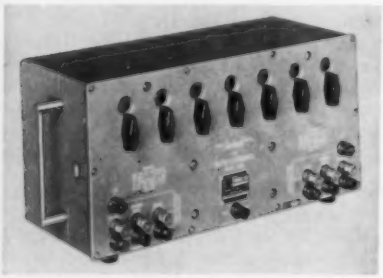
Systematics, a division of General Instrument Corp., is marketing the Model D875 Universal Code Punch and Verifier System. The Model D875 is designed to provide a fast, accurate and economical means of manually punching and verifying from an original document into paper-tape machine language. The system has combined tape keypunching and verifying functions into one integrated system, eliminating weaknesses inherent in makeshift approaches to the preparation of input to paper tape-oriented computers.

The unit punches and verifies for all systems—5, 6, 7, or 8-channel tape, any code structure. The system is built around the same keyboard used on the IBM Card Punch—the best-known keyboard in the data processing industry. The D875 System consists of an alphanumeric keyboard, a paper tape punch, a tape reader, and interconnecting control circuitry. In addition to keypunching and keyverifying, the system is capable of flexible tape duplication—automatically or intermixed with punching and verifying—at any speed up to 20 characters per second.

Circle No. 225 on Subscriber Service Card

A-C Ratio Standards

Gertsch Products, Inc. is marketing a line of precision ratio standards with a-c ratio accuracy to 0.0001%. Units are certified in terms of a standard which is directly traceable to the National Bureau of Standards. Designated Series 1000, these instruments are precision transformer voltage dividers combined with precise resistive dividers. Basic ratio sections include high-frequency a-c, low-frequency a-c, and d-c. A-c sections feature maximum ratios up to 1.111111, and minimum ratios down to −.11111. Units provide switching transient suppression, 6- or 7-place resolution, and terminal linearity of 0.0001%.



Circle No. 226 on Subscriber Service Card

Glass Antenna Reflectors

Close-tolerance fiber glass antenna reflectors which could be used to measure radiation from other planets soon will be marketed to government and industry agencies by The Boeing Co. Capable of holding their shape under heavy wind forces and extreme temperatures and giving stronger focus to radio waves, antennas equipped with the new reflectors could also be used to track satellites or to transmit and receive long-range communications.

Circle No. 227 on Subscriber Service Card

Size 8 Resolvers

Daystrom's Transicoil Division has available a complete line of Size 8 Resolvers which meet light weight and temperature-stable applications. The transicoil resolver is designed so that stability is accomplished without an increase in weight. Stability over the entire temperature range (−55° to +125°C) is inherent in the design. These units are constructed of corrosion-resistant materials throughout and comply with all applicable portions of MIL-E-5272.

Circle No. 228 on Subscriber Service Card

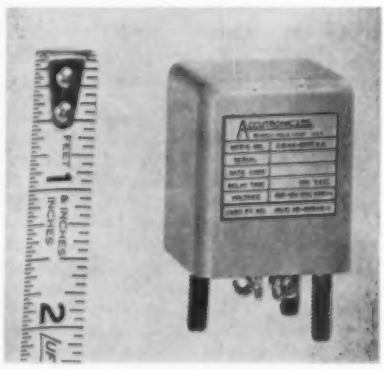
Decommutation Station

Parsons Electronics is marketing a PAM/NRZ/PDM telemetry decommutation station with design simplicity and operational flexibility. Standard IRIG telemetry signals and non-standard rates from the output of a telemetry receiver, subcarrier discriminator, tape, or signal simulator are accepted, processed and demodulated by Model 5400. Major components of the system are pulse selector, gate generator and patch panel, power supply, and combinations of demodulator chassis and plug-in units. Building-block construction permits expansion of basic station capabilities up to 100 channels.

Circle No. 229 on Subscriber Service Card

Miniature Time Delay Relay

A solid-state timing device in miniaturized version is available from Accutronics, Inc. as either delayed break after make or delay on make. These units provide delay periods of from 0.025 to 180 seconds and may be had as either fixed time or variable assemblies. They are manufactured in compliance with all applicable MIL specifications. Standard relays are DPDT 2.5 A resistive; input voltage 22 VDC to 30 VDC. Timing intervals remain constant over a wide range of environ-



mental conditions and will withstand 100 g shock for 11 milliseconds and a vibration of 55 to 2000 cps at 30 g. These units comply with all requirements of MIL-E-5272C for environmental conditions. They are completely encapsulated and have glass-sealed headers in standard MIL enclosures.

Circle No. 230 on Subscriber Service Card

Linear Accelerometer

A hermetically-sealed 3-axis linear accelerometer with range capability all the way from ±2 g's to ±200 g's is available from Humphrey, Inc. The

miniature device provides information on linear acceleration along three different axes, replacing multiple instruments and saving space, weight and cost. Accuracy of the instrument is 1%. Three 5000-ohm potentiometers provide the output. The unit is suitable for rugged environments such as are found in missile applications, including operating temperatures from 0°C to 100°C, shock of 30 g's for 20 milliseconds and vibration without damage of 10 g (0.06 DA MAX) 5-2000 CPS. It can be used at unlimited altitude and 100% humidity.

Circle No. 231 on Subscriber Service Card

Cryogenic Sensors

Two cryogenic sensors, each about the size of a nickel and said to accurately measure temperatures as low as 4° Kelvin (−260°C), have been introduced by Minneapolis-Honeywell Regulator Co. The tiny sensors are germanium semiconductors, designed for application in test and operational phases of space vehicles using liquid helium and nitrogen, and for use in calibration and standards laboratories. Their temperature range is 4° to 40° Kelvin (−269°C to −233°C). One type of sensor measures surface temperatures; the other is a probe-type unit for internal applications. Both are encapsulated and hermetically sealed. Thermometer elements are precision-doped with special impurities to provide high thermometric sensitivity.

Circle No. 232 on Subscriber Service Card

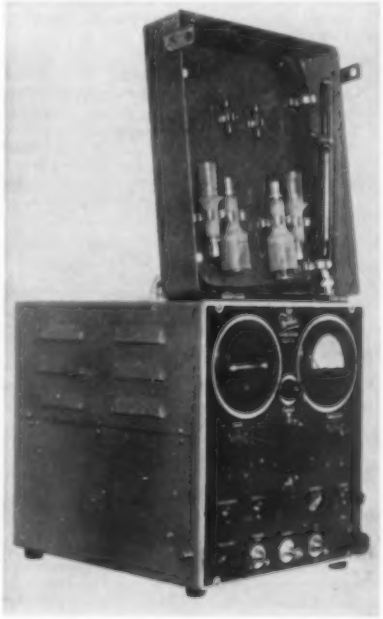
Fiber Optics Cathode Tube

Development and availability of cathode-ray tubes with fiber optical face-plates is announced by the Electronic Tube Division of Allen D. Du Mont Laboratories. The use of fiber optics permits the image, trace, or display on cathode-ray tubes to be brought directly to the outside surface of the face-plate so that all parallax is eliminated. Normal light transmission efficiency of about 6.3% using a lense system is increased to 85-90% using Fiber Optics Cathode-Ray Tube or Coupling. Although the first available Du Mont fiber optics cathode-ray tubes are 1-7/16-in.-diameter tubes, the firm can provide tubes in sizes up to 5-in.-diameter and will undertake development programs for large display tubes where the matter of parallax is of major consideration.

Circle No. 233 on Subscriber Service Card

Adhesive Bond Tester

In direct proportion to the growing application of bonding is the need for rapid, non-destructive methods of testing the strength of such bonds. One of the leaders in this field, the Dutch firm, Fokker Aircraft, has perfected an apparatus for testing various forms of adhesive bonds without in any way applying destructive forces to the bonded materials. The unit is equipped with a probe, which is placed on the area to be tested. The bonded structure is then "tension-loaded" in the same manner as during flight; that is, laminates in shear-tension and sandwich configuration in flatwise-tension. The bond tester simultaneously measures the results of the probing on two parameters, by

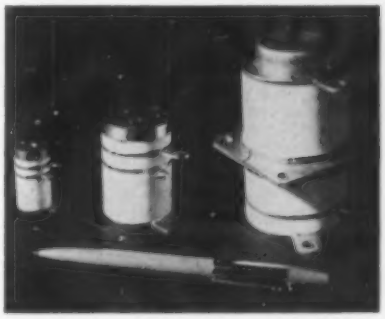


which a thorough indication of the quality of the bond is obtained. In actual application, however, one parameter is usually sufficient.

Circle No. 234 on Subscriber Service Card

High-Temperature Diodes

General Electric's Power Tube Department has developed three new high-temperature diodes that operate in sustained ambient temperatures up to 500°. The tubes were designed for use in a high-temperature generator regulating circuit for Mach 3 aircraft, as well as for other military aircraft and missile applications. All three tubes, which are of ceramic construction and



filled with an inert gas, are available in limited quantities for engineering samples. Their current ratings range from 0.15 amperes to 10 amperes.

Circle No. 235 on Subscriber Service Card

Preamplifier/Rejection Unit

Kearfott Division, General Precision, Inc., has available the C70 3117 001 Preamplifier and Quadrature Rejection Circuit for various military and industrial applications. Economical operation is effected by utilizing low-cost, low-gain servo amplifiers with this unit. Identical servo amplifiers can be used in either high- or low-gain servo loop designs. In servo loops requiring high gain, the C70 3117 001 unit is used with a low-gain amplifier, and where low gain is required the Quadrature Rejection Circuit (D4821-01) is used without the preamplifier.

Circle No. 236 on Subscriber Service Card

Permanent Magnet

A permanent magnet, ALNICO VIII, available from Crucible Steel Co., has over twice as much resistance to demagnetization as ALNICO V, and is substantially higher in both coercive force and maximum energy product than ALNICO VI or VII. In the past, it was impractical to use permanent magnets in many applications because of severe temperatures and other environmental conditions. ALNICO VIII now makes practical design possible.

Circle No. 237 on Subscriber Service Card

contracts

NASA

$533,000—**United Nuclear Corp.**, New York City, for design and manufacture of a 1000 kw liquid metal heat transfer loop for Lewis Research Center.

$100,000—**Boeing Co.**, Seattle, for determination of the most effective method of clustering solid-rocket boosters.

North American Aviation's Space and Information Systems Division, Downey, Calif., for two *Little Joe* space boosters. No amount disclosed.

North American Aviation's Space and Information Systems Division, Downey, Calif., from Marshall Space Flight Center, for development of mathematical techniques to provide the mechanics for satellite rendezvous. No amount disclosed.

MISCELLANEOUS

$4,000,000—**Consolidated Vacuum Corp., Bell & Howell Co./CEC subsidiary,** Rochester, N.Y., from California Institute of Technology Jet Propulsion Laboratory, for a space environmental simulator to test the ultimate design of spacecraft.

$500,000—**Sanders Associates, Inc.**, Nashua, N.H., for production of subminiature rate gyros for the North American Search and Ranging Radar system.

$102,626—**Collins Radio Co.**, Dallas, from California Institute of Technology (JPL), for installation and maintenance engineering assistance on the JPL Deep Space Instrumentation Facility, Johannesburg, South Africa.

NAVY

$6,500,000—**Westinghouse Electric Corp.**, Baltimore, for production of Mark 45 torpedoes.

$1,460,000—**Boeing Co.**, Seattle, for design and contraction of a 15-ton twin-hull hydrofoil test craft to be used as a test bed for development of "supercavitating" hydrofoils.

$99,500—**General Precision, Inc.**, Tarrytown, N.Y., from Air Development Center, Johnsville, Pa., for development of performance specifications for a data processing system and associated displays for a new manned-aircraft antisubmarine warfare application.

ARMY

$4,048,005—**Collins Radio Co.**, Dallas, for radio terminal set for use with the *Pershing* missile.

$2,900,000—**Bendix Corp.**, Detroit, for electronic equipment for the shipboard terminal of Project *Advent* communications satellite; development of satellite communication equipment, associated ground communication terminals and pre-launch satellite checkout equipment for *Advent*.

$1,251,119—**Martin Co.**, Orlando, Fla., for *Pershing* weapon system. (7 contracts.)

$1,000,000—**Cubic Corp.**, San Diego, Calif., for production of Geodetic SECOR equipment.

$828,962—**Western Electric Co.**, New York City, for *Nike* replenishment spare parts. (3 contracts.)

$532,269—**Lamtex Industries, Inc.**, Farmingdale, N.Y., for production of chemical rocket shipping and firing containers.

$366,858—**Douglas Aircraft Co.**, Santa Monica, Calif., for *Nike* replenishment spare parts. (3 contracts.)

$235,425—**Martin Co.**, Orlando, Fla., for concurrent repair parts and modification kit for *Lacrosse* missile system.

$119,324—**Martin Co.**, Orlando, Fla., for replenishment spare parts for *Lacrosse* weapon system.

AIR FORCE

$37,130,467—**IT&T's Federal Electric Corp.**, Paramus, N.J., for operation, maintenance and support of the Distant Early Warning (DEW) Line for FY 1962.

$14,980,000—**Avco's Research and Advanced Development Div.**, Wilmington, Mass., for continued development on re-entry vehicles for *Titan* and *Atlas* ICBM's;

$14,647,500—**Avco's Lycoming Div.**, Stratford, Conn., for follow-on production of re-entry vehicles, spares and associated ground support equipment.

$12,950,000—**General Dynamics/Fort Worth**, for Category I flight test of B-58.

$7,809,000—**Hercules Powder Co.**, Magna, Utah, for work on *Minuteman* third stage.

$4,861,641—**U.S. Underseas Cable Corp.**, Washington, D.C., for extension of Atlantic Missile Range cable system. (2 contracts.)

$4,500,000—**Pittsburgh-Des Moines Steel Co.**, Pittsburgh, for steel fabrication to be used in second phase of *Titan II* missile project, Wichita, Kan.

$3,400,000—**AC Spark Plug Division, General Motors,** Flint, Mich., for depot maintenance for *Thor* guidance system and related ground equipment.

$3,137,530—**Goodyear Aircraft Corp.**, Akron, Ohio, for modifications of *TM-76A Mace* missile.

$2,250,000—**Martin Co.**, Orlando, Fla., for production of the nuclear warhead *GAM-83B Bullpup* air-to-surface missile.

$1,687,128—**Ryan Aeronautical Co.**, San Diego, Calif., for production of kits, components material, services and data for *Q-2C* target drones.

$1,395,250—**Aerojet-General Corp.**, Azusa, Calif., for production of liquid-propellant rocket sled system and components.

$1,207,000—**General Electric Co.**, Syracuse, N.Y., for depot maintenance of *Atlas* guidance subsystems and ground support equipment.

$1,000,000—**General Atomic Div., General Dynamics Corp.**, San Diego, for classified research.

$1,000,000—**The Siegler Corp.**, Los Angeles, for design and installation of electronic and antenna equipment for space and satellite programs.

$725,000—**The Siegler Corp.**, Anaheim, Calif., from **The Martin Co.**, for production of video systems for operational sites of *Titan* ICBM's.

$500,000—**Fairchild Semiconductor Corp.**, Mountain View, Calif., from **Boeing Co.**, for transistors for *Minuteman* program.

$350,000—**Republic Aviation Corp.**, Farmingdale, N.Y., for development of rivets, bolts, and other mechanical fasteners which can withstand space environment.

$199,000—**University of Michigan**, Ann Arbor, for study of the transfer of heat by boiling liquid metals.

$157,226—**Colorado Research Corp.**, Broomfield, Colo., **subsidiary of Bell & Gossett Co., from General Electric Co.**, for design and manufacture of microwave refractometers for a new Missile Trajectory Measurement System (MISTRAM).

$64,000—**Microwave Associates, Inc.**, Burlington, Mass., for development of microwave plasma amplifiers.

$50,000—**Westinghouse Electric Corp.**, Lima, Ohio, for a 4000-watt solar power system suitable for use in earth-orbiting satellites.

Atlantic Research Corp., Alexandria, Va., for production and flight testing of new "three-finned" version of *Iris* rocket. No amount disclosed.

Talley Industries, Inc., Phoenix, Ariz., for production of a new solid-propellant ballistic actuator for the *Titan II* missile silo program. No amount disclosed.

Oxygen Tests

(Continued from page 27)

on themselves, and reported on environmental conditions. These reports were given during 6-minute intervals every 90 minutes, simulating conditions in an earth orbiting laboratory. Other communication was strictly limited.

Work-rest cycles also were studied. The two men manned the cabin's performance panel 20 hours a day in shifts varying in length from two to five hours. Careful performance records were kept on an electronic console outside the "cabin."

The tests were conducted in SAM's Space Cabin Simulator, built by Minneapolis-Honeywell's Aeronautical Division. The manned satellite simulator is an elliptical steel tank 8 ft. high by 12 ft. long equipped with facilities like those which might be found in a space vehicle. Closed-circuit television cameras are concealed behind the control panel and the subjects are constantly observed, although they have the illusion of isolation.

The two subjects who just completed testing exhibited no antagonistic reactions to each other during the long confinement. However, they were friends of long standing, having been stationed together in Japan. Some earlier confinement tests—30 days in duration—had produced some friction between test subjects. ⌗

Predetection Recording

(Continued from page 26)

In the predetection recording method, the base line shift does not occur when speeds are reduced, since the frequency of a sine wave is merely reduced in direct proportion to the change in playback speed. No degradation of data occurs, therefore, and in addition, the low end of such a system can be d-c.

Both linearity and amplitude stability of a predetection recording system can be quite high, Tobias said. He pointed out that linearity can be within 0.1% and amplitude stability can be within 0.5% across an entire roll of tape. The excellent amplitude stability possible makes a PAM/FM or PACM/FM system feasible.

Bias and record level settings are less critical than for other types of recording systems, Tobias continued, because sine waves are recorded instead of postdetected data in square wave or pulse form.

Equipment necessary for the predetection recording setup is easily available, he said, and the entire system—consisting of receivers, detectors and re-

corders—is interconnected by BNC connectors. Setup and checkout time is approximately five minutes.

Equipment includes a receiver in which the final stage of the IF limiter output from the receiver has been heterodyned to 600 kc. Such receivers have discriminator-type detection devices built in so that on playback the IF is detected and converted to a video output signal. This type of equipment eliminates accessory discriminators unless speed reduction is required on playback, at which time a counter-type discriminator can be used. ⌗

Six Stations Will be Able To Order Mercury Re-entry

POINT ARGUELLO, CALIF.—Six of the 18 globe-girdling tracking stations supporting Project *Mercury* orbital flight will have direct voice communication with the capsule and the capability to command re-entry.

Typical of the command stations is the one located at Point Arguello on the Pacific Missile Range. If re-entry command from the Kauai Island, Hawaii, station fails, Point Arguello will be able to reset the switch for retro-rocket firing.

Main console in the PMR *Mercury* Room has three stations:

—Middle station is the capsule communicator's console, which may be manned by one of the seven astronauts. The capsule communicator will be in voice communication with the orbiting astronaut and will see displayed on his console the time of day, time elapsed since launch, remaining time for retro-rocket firing, and, at the bottom, a photograph of the control board in the capsule.

—The aeromedical console, on the communicator's left and operated by a Navy bio-science officer, will monitor the astronaut's oxygen supply, body temperature, respiration and pulse rate. In the center of this console is an electrocardiograph screen. All data is displayed on a strip chart recorder.

—The systems monitor console, on the communicator's right and manned by a member of NASA's Space Task Group, will monitor spacecraft systems operation, displaying pressure, temperature, fuel, roll, pitch and yaw.

Across the room from the main console is a plotting board and the communications technician's console for selection of transmitters and receivers during capsule-station communication.

The station's tracking and receiving equipment is located on two mountain peaks about 2000 ft. above sea level.

Other command stations are at Cape Canaveral, Bermuda, Woomera in Australia, and on Grand Canary in the Canary Islands. ⌗

when and where

JULY

Western Plant Maintenance and Engineering Show, Pan Pacific Auditorium, Los Angeles, July 18-20.

Structural Engineering Aspects of Atomic Shelter Seminar, Pennsylvania State University, University Park, July 23-Aug. 4.

Electronic Maintenance Engineering Association Exhibition and Symposium, Mayflower Hotel, Washington, D. C., July 24-26.

Differential Equations in Non-linear Mechanics, AFOSR, cosponsored with Martin's RIAS Div., Air Force Academy, Colorado Springs, Colo., July 31-Aug. 4.

Physics of the Solar System and Re-entry Dynamics, National Science Foundation, NASA, Virginia Polytechnic Institute, Blacksburg, July 31-Aug. 11.

AUGUST

Space Age Astronomy, symposium sponsored by Douglas Aircraft Co., Cal-Tech, Pasadena, Aug. 7-9.

American Rocket Society/Stanford University, Guidance and Control Conference, Stanford University, Palo Alto, Calif. (Some sessions classified), Aug. 7-9.

Society of Photographic Instrumentation Engineers, 6th Annual Technical Symposium, Ambassador Hotel, Los Angeles, Aug. 7-11.

Survival in the Nuclear Age—Executive Management Seminar, Pennsylvania State University, University Park, Aug. 13-18.

International Astronomical Union, 11th General Assembly, Pasadena, Calif., Aug. 15-24.

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Shuffleboard on the Moon

IF YOU PLAY shuffleboard, you know that scoring depends not only on getting your own weight in a good position but also in knocking your opponent off the board. It's an exciting, competitive game.

NASA's big shuffleboard game on the manned lunar program got under way last week with the industry-wide *Apollo* conference attended by representatives of some 360 firms. There were several clever maneuvers for position and some pretty good efforts at knocking the other fellow off the board. It was the kind of competition that can result in a technologically healthy program.

But let's imagine for the moment a shuffleboard game played under rather strange rules. Just as you edge past your opponent into a good position, the referee picks up your weight, puts it in his pocket, and declares, "This is mine." You would feel quite rightly that your chances of winning were being somewhat compromised.

Yet this is what NASA, in effect, is doing to a number of firms in the *Apollo* competition. Feasibility study contracts which went to the three firms in California, Maryland and Pennsylvania were quite limited financially. Little of the money filtered down to the subcontractors aligned with these three teams.

These firms gambled considerable amounts of their own capital in studies of guidance, propulsion and other aspects of the manned lunar program. The primes, including those which did and did not receive one of the three study contracts, also put their own money—quite a bit of it—into the design studies which they unveiled last week.

Some of the industry's more far-sighted firms have been at work on manned lunar systems and subsystems for several years, these company-funded programs antedating the NASA feasibility contracts and extending at times to experimental hardware.

On arrival in Washington for the *Apollo* conference, representatives of these firms found they were expected by NASA to throw all their know-how into the kitty for the "benefit" of the nation's all-out effort to beat the Russians to the moon.

Once again, proprietary rights were out the window.

It's about time something concrete was done about the question of proprietary rights. Ours presumably is a society based on economic, democratic capitalism, not communism. We count on competition among private firms to keep us ahead of the Russians. A great deal of lip-service is paid to this by prominent government officials.

Yet, on what is true competitive advantage based, if not upon know-how of the competing firms? To dispossess a company of its know-how is to take away its winning weight on the shuffleboard.

It is a fallacy to assume that this will benefit the nation in reaching its goals—a fallacy, that is, if you believe in our type of economic system. If we are going to do it the other way, let's call ourselves communistic and be done with it.

Few industry representatives question the government's right to data developed in programs that are 100% government-financed. It is in insistence on a right to this data from other programs that the difficulties arise.

NASA, with an opportunity to develop new guide lines on proprietary rights, unfortunately seems to be following the questionable policies of the Department of Defense.

Armed Services Procurement Regulation IX Part 2 contains this statement: "It is the policy of the Department of Defense to encourage inventiveness and to provide incentive, therefore, by honoring the 'proprietary data' resulting from private developments and hence to limit demands for data to that which is essential for government purposes."

Unfortunately, DOD has too sweeping a notion of what is essential for government purposes. It is disheartening to see NASA going the same route.

A NUMBER of responsible missile/space industry executives are deeply disturbed by the government's cavalier attitude toward proprietary rights.

Mr. Denham S. Scott, assistant to the president, Garrett Corp., writing in the current issue of the monthly magazine *Aircraft & Missiles*, suggests that the present impasse can only be broken by a willingness by both parties to compromise.

He suggests that all requirements for data should be a separate contractual item, with the needs and the rights clearly out in the open so each party can negotiate intelligently. Mr. Scott also points out the dangers inherent in unqualified acceptance of competitive bidding on parts which have been developed by an individual firm under government contract.

"The low bidder in a typical competitive bid is not necessarily bidding on the same thing as the designer, and the millions of dollars spent for safety and reliability are sometimes sacrificed on the altar of false economy," he writes.

For a procurement officer to snap that "If they don't like it, they don't have to stay in the business," is not a satisfactory answer. In the competition with the Soviet Union in the decade ahead, every bit of industrial skill this nation possesses must be available to the government.

Anything that threatens the enthusiasm and willingness of private firms to participate in government programs endangers our chances of survival as a nation. Missile/space industry firms are willing to gamble time and capital in programs such as *Apollo*. But they must be assured that they will not be denied the benefits of their efforts.

The *Apollo* program would be an excellent one on which to get a fresh start on the problem of proprietary rights.

William J. Coughlin

UNSEEN BUT NEVER LOST. *Far down in the secret depths of the sea America's Polaris submarines can cruise for many weeks, poised for free world defense. Without surfacing, men of these submarines can pinpoint their exact position constantly. The equipment to perform this precise duty is called Mark II SINS (Ship's Inertial Navigation System). The first operational SINS was designed, built, and delivered in record time by Autonetics.*

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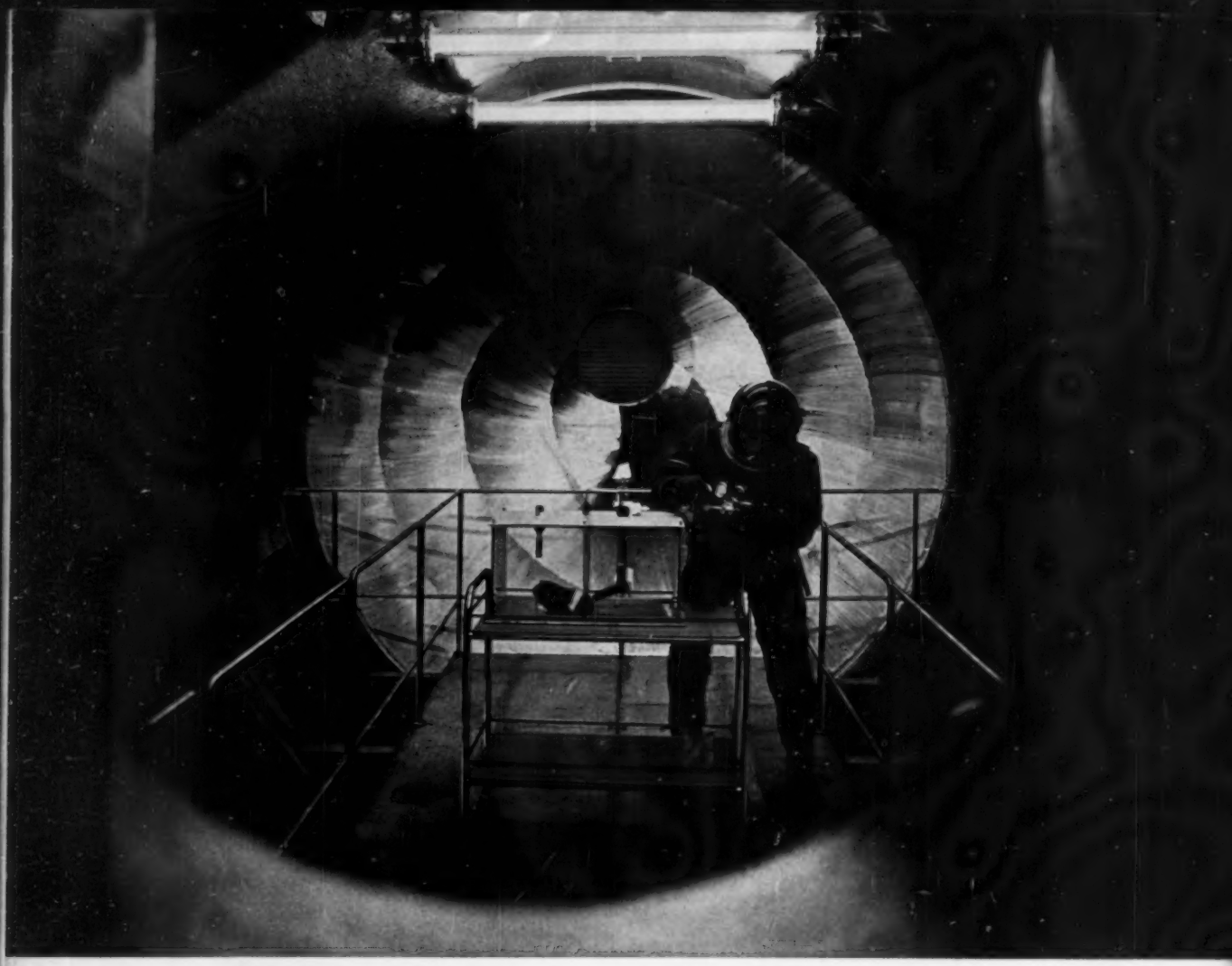

The Uses of Space

Man is the searcher. He has a driving urge to know. After centuries of speculation, we now know that the world of space is infinitely more vast even than in our dreams. How shall we rise to the challenge of space knowledge? Ask any scientist and he will tell you: space is not something to be conquered but to be used--for reconnaissance, instant world-wide TV and radio communications, weather forecasting and basic research. Where will it all end? It never will.

Shown above is one feature of Republic's Space Environment and Life Sciences Laboratory, largest space chamber in the nation capable of testing men and space systems at simulated altitudes of more than 150 miles. Republic's new Research & Development Center is the only fully integrated industrial research complex engaged in every vital area of space investigation. Eight laboratories comprise the Center: Space Environment and Life Sciences; Re-Entry Simulation; Materials Development; Nuclear Radiation; Electronics; Guidance and Control Systems; Fluid Systems; Transonic, Supersonic and Hypersonic Wind Tunnels. Behind Republic's record of military aircraft success is the idea of man as the "irreplaceable element." This same concept is the basis of Republic's wide-ranging exploration of every field of space knowledge.

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